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A SOUTH AMERICAN AERIAL ROPE RAILROAD.

By the English Correspondent of Scientific American.

South America, especially the Argentine, has been the scene of many remarkable railroad engineering feats for the provision of communication between difficult and inaccessible districts, more particularly which have prevented the mines of Famatina from being exploited, notwithstanding the fact that their abundant wealth in gold, silver, iron, and copper has long been fully realized. The location of this district is particularly wild and inaccessible. It covers an area of about 160 square miles, and lies in latitude 29 south and between 68 and 69 west longitude. The surrounding mountains are particularly precipitous, tropical, while the temperature at Upulungos during the winter is often well below 0 deg. F. Moreover, the surrounding country is particularly arid and barren, water and wood being practically non-existent. These peculiar conditions have militated against the mines being fully worked, although it has been possible to dispatch from 3,000 to 4,000 tons of rich ore to Chilecito every year.

THE LINE FOLLOWED BY THE ROPEWAY LIES OVER THE MOUNTAINS.

ONE OF THE WIDER VALLEYS CROSSED IN A SINGLE SPAN.

A SUPPORTING TOWER, SHOWING THE UP AND DOWN LINKS.

TUNNEL, 1,000 FEET LONG, THROUGH THE MOUNTAINS 14 MILES FROM CHILECITO.

A SUB-STATION ON THE LINE, SHOWING THE CHARACTER OF THE COUNTRY.

A SOUTH AMERICAN AERIAL ROPE RAILROAD.

among the Andes. This lofty and rugged mountain range possesses many districts remarkably rich in minerals, but the regions are so isolated by reason of towering peaks, which offer almost insurmountable obstacles to the railroad engineer, that they cannot be brought into connection with the important centers without involving expenditures so great as to be almost impossible of recoupment. The result of this has been that the development of the mining districts has been retarded, the only communication possible being maintained by mule transport over the precipitous mountain trails. Obviously, such transport is slow, difficult, and expensive. It is these factors rugged, and of great height. The most important mine of the district, at Upulungos, is situated at an elevation from 15,400 to 16,400 feet above sea level. The nearest township is Chilecito, some 30 miles distant, though considerably more over the winding mountain roads, and communication between the two points had to be maintained by mule carriers, a journey which occupied several days. Moreover, owing to the extreme elevation work at the mine can be carried out with extreme difficulty only owing to the rarefied atmosphere combined with the wide variations in temperature. The climate at Chilecito, which is at an elevation of [illegible] above sea level, is

However, when the Argentine government extended the railroad to Chilecito, the most westerly point of the whole system, bringing the township into direct communication with Buenos Ayres, an English company acquired the property, with the object of exploiting it upon an extensive scale. The Argentine government was approached, and the urgency of better and more expeditious transportation facilities between Famatina and Chilecito was forcibly impressed upon the latter, so that at last the Ministry of Public Works undertook to connect the mines with the railroad head at Chilecito. The continuation of the trunk line from the latter point, or the construction of a light railroad,

was conceded to be impossible, so that at last it was decided to connect the two points by means of an aerial rope railroad available for both freight and passenger traffic, and the contract for the undertaking was awarded to the Bleichert Company, of Leipzig, Germany, who have built a number of railroads upon this principle, especially in Switzerland.

This aerial ropeway is the largest installation of this type that has yet been completed. The total length of the line is approximately 21 miles, and the difference between the levels of the terminal stations is about 11,600 feet. The nature of the country traversed may be graphically realized from the accompanying illustrations, which also afford some idea of the difficulties encountered in its construction and in the transport of the requisite material from the depot at Chilecito to the point of erection. The line is in duplicate, and it is divided into up and down sections respectively. There are two wire cables, one being the main carrying rope and the lower the guide rope for either service. The guide rope is always in motion, and as with an ordinary funicular railroad a portion of the momentum of the descending cars is utilized for those which are ascending, but in the lower levels this power is supplemented.

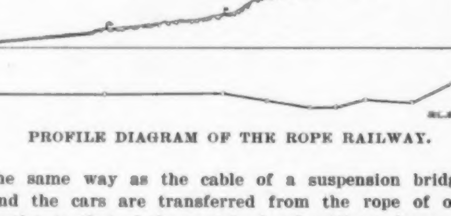
Owing to the rugged nature of the mountain peaks and slopes traversed, many engineering difficulties had to be overcome. Cuttings had to be made, and in one spot 14 miles from Chilecito a tunnel had to be bored through the mountain at an elevation of 8,400 feet above sea level, for the passage of the ropeway. The steelwork required for the supporting towers and substations had to be built of the lightest material consistent with the maximum of strength, and those sections which did not require transportation intact, such as boilers, were made in short convenient lengths, so as to pack on the mules in the most compact manner.

The line is divided into eight sections, there being seven stations between the two respective termini of Chilecito and Upulungos. The distances between the substations vary between 5.5 and 1.2 miles according to the nature of the country, the gradient of the line, etc. For the most part the gradients average between 5 and 30 per cent; but at places, owing to the precipitous nature of the mountain slopes, gradients of 1 in 1 were found to be unavoidable. One of the steepest parts of the line is the sixth section, rising from El Cielito, 10,463 feet above sea level, to Calderita Nueva, 12,832 feet, a total rise between the two points of 2,369 feet in 8,700 feet. For the first 4½ miles out of Chilecito the gradient is easy and regular, rising to the highlands of the surrounding hills; and although several valleys and ravines are encountered thereafter, the rise to the second station is still gradual. From the latter point onward, however, to the opposite terminus the line is almost a continual upward climb, occasionally of the steepest character. Between the fourth and fifth stations the line crosses seven precipices, and then enters a tunnel 1,000 feet in length to the opposite side of the slope, since it was found to be impossible to surmount the peak in any other manner. This tunnel is 14 miles out from Chilecito, and it proved a tedious operation in boring through the solid rock. It is 14 feet 6 inches in width and 13 feet in height and is partially lined with brick, carrying the cross lattice girders which support the rails upon which the vehicles run, since upon this section the cable is substituted by iron rails. After issuing from the tunnel a deep and wide abyss is crossed in two spans of 840 and 1,770 feet respectively. In the upper levels, owing to the deep and wide character of the valleys, which prevented the erection of intermediate supporting towers, abnormally long spans had to be laid. In some instances these are 2,000 and 3,000 feet in length.

Wherever possible, however, steel towers for supporting the cableway are erected. For the most part they are of the trellis girder type; this arrangement, while giving an ample factor of strength when *in situ* at the same time rendered the task of transportation by mule considerably easier. The towers are located upon masonry foundations carried down and keyed to the solid rock. In all, 275 towers are distributed over the 21 miles of line, and they vary in height from 10 to 160 feet, the latter being utilized upon the higher sections, owing to the increased depth of the abysses.

The main bearing rope is of two kinds, in accordance with the prevailing conditions. Upon those sections where the load is not excessive the rope utilized is of the hollow spiral type having a breaking strain of 95.25 tons per square inch, and ranging in diameter from 1.4 inches for the down and 1.1 inches for the up lines where the gradients are steep in the upper sections to 1.2 inches for the down and 1 inch for the up lines respectively in the lower sections. At those places where wide spans could not be avoided the rope is solid, the diameter being, however, the same. At nineteen points throughout the line the rope is either anchored or braced over the supporting girders. As the guide rope is exposed to severe stresses, which at places aggregate some 11,000 pounds, it is made of steel, is 0.7 inch in diameter, and has a breaking strain of 114 tons per square inch, with a factor of safety of 4.5. On some of the sections the excess of power generated by the descent is sometimes as much as 75 horse-power, which, however, is absorbed by a brake.

The main rope is fixed, the guide rope being always in motion. The cars hang from the main rope, along the upper surface of which run the rollers carrying the car. The main rope is anchored at each station in



PROFILE DIAGRAM OF THE ROPE RAILWAY.

the same way as the cable of a suspension bridge, and the cars are transferred from the rope of one section to that of the next by hand, without, however, arresting their progress. The guide ropes also extend from one station to the next only. The cars are coupled to each rope in succession upon the Bleichert automatic system. At intervals of about 1¼ miles between the stations are installed tension stations. At these points the ropes are supported on iron girders, some of which have stretchers or braces, by means of which the required tension of the ropes can be maintained. At the substations are installed boiler and steam-engine plants for driving and starting the cars. The vehicles, however, are not intercepted or stopped at these intermediate stations, but are express between the mines and Chilecito.

The cars have a capacity of 10.6 cubic feet, and each carries 1,100 pounds of ore, giving a total weight inclusive of that of the car itself of 1,500 pounds. The maximum loads are 20 tons on the up and 40 tons on the down journeys. There are also provided cars for the transport of provisions, stores, material, etc., and also one vehicle for passenger traffic having seating accommodation for four persons. Owing to the great difficulties encountered in obtaining adequate supplies of water in the higher altitudes around the mines, this commodity is also sent up from the lower levels, there being special tanks slung to the line for this purpose. The average speed of descent is 500 feet per minute, and the cars follow at intervals of 45 seconds and at distances of 369 feet.

One of the most [illegible] of the enterprise was in connection with the laying of the cables. The main cables were coiled up in lengths ranging from 650 to 1,000 feet, and, weighing about 6.75 pounds per foot, represented a total weight ranging from 4,387 to 6,750 pounds. As the maximum weight allowed to each mule was only 330 pounds, and the heavier sections, such as the boiler plant, etc., up to a maximum of two tons, were conveyed by carriers, these main lengths of ropes exceeding this height had to be carried by porters. The ropes upon arrival at the depot at Chilecito were unwound, separated into coils without breaking them, and each length was carried by a number of men ranging from 60 to 300 according to the length of the rope. As the head of the line was pushed forward the cables were sent by the cableway in similar manner attached to a train of cars, and at the railhead were paid off to the waiting gang of porters, who carried them along to the required point of erection, as shown in the accompanying illustration.

The system adopted for keeping the ropes thoroughly lubricated constitutes a noticeable feature of the undertaking. For lubricating the main rope there is a small car mounted on rollers and containing a small rotary pump and reservoir containing the lubricant. This car is sent along the rope, and the rotation of the wheels actuates the pump, which projects a stream of oil on to a brush, which in turn distributes the lubricant over the rope. The guide rope, however, is oiled at the stations, the lower part of the pulley in its passage passing through a bath of oil or varnish.

The construction of this ropeway took a little more than fourteen months, and required 1,200 men and 1,000 mules. The cost of construction varied, naturally, according to the altitude at which the work was carried out, the charges at an elevation of 14,000 feet being 50 cents per foot, and the wages 9 cents per foot for local labor, the cost in regard to the European workmen who carried out the finer and more delicate operations ranging from $1.50 to $3.75 per day, according to the character of the work upon which they were engaged. The cableway upon completion was taken over by the Argentine government, by whom it is now operated, but its provision has already appreciably influenced the fortunes and output of the mining district. Whereas under the former mule transport system the charges were $12.50 per ton for conveyance from one point to the other, representing about 50 cents per ton-mile, by the cableway with the maximum delivery of 40 tons per hour the charges are reduced by nearly 90 per cent, being $1.26 per ton, or practically 6 cents per ton-mile. The company which has acquired the mines have their copper-smelting

THE ENTRANCE TO THE 1,000-FOOT TUNNEL THROUGH WHICH THE CABLEWAY PASSES. NOTE THE TELEPHONE LINK.

A SOUTH AMERICAN AERIAL ROPE RAILROAD.

works at Chilecito, and the cableway is connected thereto, the cars with their loads of ore being conveyed direct into the works, run on to an automatic weighbridge, checked, and their contents then discharged into hoppers.

SOME POSSIBLE DEVELOPMENTS OF THE GAS ENGINE.

POSSIBLY all builders of the steam engine, even those most thoroughly convinced of the excellence of their wares, have, at times, an uncomfortable feeling that the days of steam are numbered, and that sooner or later—perhaps sooner rather than later—the commanding position now held by the steam engine as a prime mover will be taken by the internal-combustion engine. This belief is mainly founded on the greatly superior thermodynamic efficiency of the internal-combustion engine. As has, however, been pointed out by Prof. S. A. Reeve, in a paper recently read before the American Institution of Mechanical Engineers, economy of fuel has always been one of the minor virtues in the case of a prime mover, and is in general of much less importance than the more material qualities of reliability, steadiness of running, and flexibility. In fact, even the gas engine itself had found a large market long before the advent of the day in which its commercial efficiency began to be comparable with that of a steam engine. The earlier of the small gas engines certainly cost more for fuel than a small steam engine of equal power, but this drawback did not prevent their use in very large numbers, being compensated for by their great handiness, particularly when working on an intermittent load. Even after years of experiment, a fair-sized gas engine, running on town gas, requires some 20 cubic feet of gas per brake horse-power, which, at 2s. 6d. per 1,000, makes the fuel cost about 3-5d. per brake horse-power. A small steam engine, even if a steam eater, taking 45 pounds to 50 pounds of steam per brake horse-power, would not consume more than 6 pounds of coal, which in many districts would cost well under ½d. Even so, however, the great convenience of the gas engine for small powers led to the development of a large trade in them, clearly showing that other considerations than those of fuel economy commonly govern the choice of a source of motive power. In a similar way, the steam engine may still hold its own for many years to come, even though the advent of the producer has given the gas engine a much cheaper supply of fuel than was formerly available.

There is perhaps a tendency to overrate the advantage thus reaped by the gas engine. Undoubtedly, in plants of medium size, the internal-combustion engine has now often a marked superiority in the cost of its fuel as compared with that required for a steam plant of equal capacity, and this pre-eminence becomes the more marked the greater the proportion the freight charges bear to the local selling price of the fuel. In the larger sizes the steam engine is not quite so hopelessly outdistanced in the matter of fuel-cost by its newer rival. A good gas engine, working with producer gas, may be expected to require about 9-10 pound of anthracite per brake-horse-power hour. This result is certainly better than can now be obtained with steam plants even of the largest size. In the well-known test of the Carville turbine, where the steam consumption was reduced to just over 13 pounds per kilowatt-hour, the corresponding fuel consumption was presumably at least somewhere about 1¼ pounds per brake-horse-power-hour. Of course, the fuel here used was not anthracite; but, on the other hand, vacua of 29 inches or so are impracticable save in the depth of winter. This result may perhaps be improved on as further experience is gained, but it is unlikely that the fuel consumption can ever be reduced as low as now seems practicable with a gas plant running at its most economical load. Where blast-furnace gas is available, the steam plant is, of course, still more decisively beaten in the matter of reducing fuel costs, so that if these formed the critical factor in the choice of a power plant, the steady elimination of steam would be a foregone conclusion.

In all other points, however, steam yet holds considerable advantages over its rival. In spite of recent progress, it is still a much more reliable and flexible source of power than the gas engine. The latter is commonly most efficient at its maximum output, and accordingly it is very frequently rated by its makers at very nearly the maximum load it can pull. With some steam plants, on the contrary, an overload of 100 per cent can be taken over and above the rated power of the plant. In the matter of close governing, too, the steam engine still holds the advantage, many and ingenious as have been the attempts made to improve its rival in this respect. In the paper already referred to Prof. Reeves discusses these at length, and points out that with the four-cycle engine in particular the defect is an inherent one. The governor has to settle on the strength of the next impulse imparted to the piston practically a whole revolution in advance of the next working stroke. The fluctuations in speed are a maximum with hit-and-miss governing, and are much diminished when the governing is effected by throttling the charge; but this method, though diminishing the irregularities, is less economical at low loads than its cruder predecessor, since the compression falls off, *pari passu*, with the reduction in the quantity of gases drawn into the cylinder. It is quite possible to devise methods by which the clearance can be varied in correspondence with the average load on the engine, and in this way the average efficiency of an engine running on the Otto cycle could be increased by one-quarter, and the true overload capacity of the engine substantially raised. Several plausible schemes for effecting this variation in the clearance space in correspondence with changes in the load have been suggested, but Prof. Reeves claims that other methods show more promise of conferring on the gas engine some of the best attributes of its rival.

An attractive plan is that of resuscitating the Lenoir engine, with the modification of compressing the charge before allowing it to enter the cylinder. In

ERECTING THE TOWERS; SHOWING THE METHOD OF CARRYING THE CABLE BY AN ARMY OF PORTERS.

A SOUTH AMERICAN AERIAL ROPE RAILROAD.

the old Lenoir engine, it will be remembered, a mixture of gas and air was drawn in during the first half of the out-stroke of the piston. The charge was fired at mid-stroke, and did its work of propelling the piston during the second half of this stroke. There was an impulse every revolution, and the engine was governed by throttling the charge. The objection to the engine lay mainly in its extravagant consumption of gas, owing to the absence of compression; since, although, as already stated, fuel economy is not the main quality required in a prime mover, it forms nevertheless a factor which cannot be entirely ignored. From a mechanical standpoint the cycle had many advantages. By compressing the charge before it enters the cylinder most of the advantages of the cycle are retained, while an even higher efficiency should be possible than is now commercially practicable with the Otto cycle, since by using stage compression with an intercooler between the successive cylinders very high compressions would be practicable. The addition of this external compressor does, of course, complicate the plant, though this drawback would be compensated for in some cases, at least, by the facility with which the engine could be rendered reversing.

The cycle is, however, obviously unfitted for small powers, but may be worth further investigation in regard to its applicability for large units, where the presence of the separate compressor might be less objectionable. The low-pressure cylinder of the latter should be nearly equal in size to the motive cylinder, and probably the compressing plant would cost nearly as much as that actually doing the work. The engine would, however, possess many of the best features of the steam engine, and could be designed so as to take a considerable overload without much loss of efficiency, while it would also be the equal of its rival in the matter of securing an even turning speed without an excessive fly-wheel weight. This solution, in spite of its merits, which he clearly sets forth, is rejected by Prof. Reeves in favor of another, which, in its essentials, really amounts to turning the gas engine into a kind of steam engine. His proposal is to compress gas and air into a fixed chamber, where it would be ignited. The products of combustion would next pass through a tank of water, and the mixture of these gases with superheated steam would then be used for driving the engine. In order to compete with the Otto cycle a high compression—at least 350 pounds per square inch—would be necessary, and, as in the case already considered, the scheme appears feasible for large units only.

Of course, in the interchange of heat between the hot gases and the steam there is a large loss of heat theoretically available, and to us it is extremely doubtful whether it will be possible to build a commercial engine on the plan set forth. Its advantages lie in the great reduction of the maximum working temperature, and in the possibility of compounding the engine, which has not hitherto proved practicable with gas engines pure and simple. As a consequence, the strains to be taken in an ordinary gas engine have always been enormously greater than in a steam engine of corresponding capacity. Some years ago Prof. Weightman made an instructive comparison between the maximum total pressure to be provided for in equivalent simple, compound, and triple-expansion engines. The initial pressure on the single piston of the simple engine was, he pointed out, four times as much as that on the more heavily-loaded piston of the compound engine, and seven times as much as on any piston of the triple-expansion engine. The gas engine works under still more trying conditions than the simple steam engine, and this fact has been emphasized in practice by frequent broken bed-plates during the earlier years of the development of the large gas engine. Again, it is the practical necessity of expanding the charge wholly in one cylinder which renders necessary the use of liners 2½ inches to 3 inches or more in thickness in the case of large engines, and this necessity would be avoided by the adoption of compounding, which appears quite practicable with the cycle just set forth.

There is also some reason to believe that the inefficiency of the suggested plan of operations is not, in practice, fairly represented by the quantity of heat theoretically available in the products of combustion in their initial state, and in the final mixture. Extreme temperatures involve large losses from radiation and conduction, which would be almost wholly suppressed in the Reeves engine, and water-jacketing would be unnecessary. On the other hand, the suggested engine, as compared with the ordinary steam engine, would suffer from its inability to work with a condenser, since an air-pump of truly colossal proportions would be needed to remove the gases carried over with the exhaust of the engine. Actual trial of a plant of the type proposed has been made by Prof. Reeves, who claims that from the purely mechanical standpoint it ran as well as a steam engine. No figures are, however, given as to the consumption of gas or as to the probable capital cost of such a plant per rated brake horse-power. He notes, however, one very interesting point, viz., that the temperature of the exhaust from the engine was well below 212 deg. F., although the pressure was, of course, above that of the atmosphere. This was rendered possible by the large admixture of non-condensable gases with the steam. Some, at least, of the advantages of a condenser would seem, therefore, to have been successfully realized. Nevertheless, this solution of the large gas engine problem would seem too complicated to have much commercial value, interesting as it undoubtedly is from the purely theoretical standpoint.—Engineering.

To Make Felt Waterproof.—100 parts of glue are steeped for 24 hours in water, the surplus water poured off, the glue melted and 100 parts of powdered alum and a solution of 2 parts of soluble glass added to it. Enough water is then added to make the mass thinly fluid, the felt is coated with it and afterward with a strong decoction of gall nuts in water. After drying the felt is smoothed by passing between rollers.

NEW YORK AND PHILADELPHIA MOTOR BUSES.

A DESCRIPTION OF THE GASOLINE AND ELECTRIC AUTOMOBILES NOW USED FOR PUBLIC TRANSPORTATION.

BY HARRY W. PERRY.

THE motor omnibus, which has become such a prominent feature of street traffic during the last three years in London, where more than 900 are now operating on regular routes and schedules, made its debut in America last summer. It has entirely superseded the old horse stages that formerly supplied the only form of regular public vehicular conveyance on Fifth Avenue in New York city. From the start the motor omnibus service proved attractive to the public, and up to the present time its popularity has been attested by the fact that the buses usually carry passengers enough to fill most of the seats on every trip.

After experimenting at considerable expense with American-built motor omnibuses of various types, all experimental, during a period of seven or eight years, and with a French De Dion bus of 1905 model during 1907, the Fifth Avenue Coach Company put in regular service in the months of July and August last year fifteen De Dion buses of 1906 model like those shown in one of the accompanying illustrations. The running gears and machinery were imported from London, having been bought from the English agents of the French factory, and were brought over unassembled. The chassis were assembled in New York and fitted with bodies built in Philadelphia by the wagon and stage body-building firm of Fuller & Walker after the designs of the English bodies. The bodies are of the double-deck type so popular in the large cities of Europe. They have seats for thirty-four passengers—sixteen inside and eighteen on the upper deck.

These De Dion omnibuses have an overall length, from starting crank to rear lamp bracket, of 23 feet 4 inches, and an extreme width of 7 feet 4 inches. The maximum height is 12 feet 2 inches. The inside body dimensions are 11 feet 2 inches long by 5 feet 3 inches wide. The body is carried on a running gear having a wheelbase of 13 feet 10½ inches and tread of 5 feet 8 inches. Total weight of the omnibus complete without passengers is approximately 7,900 pounds, and when filled, about 13,000 pounds.

The prime mover is a De Dion gasoline engine of 100 millimeters bore and 130 millimeters stroke (approximately 4 by 5 inches) having a French rating of 24 horse-power and an English rating of 28 horse-power. The cylinders are cast separately and have integral water jackets with brass caps. An oil reservoir and pump are located in the base of the crank case. Magneto ignition is employed, with high-tension distributing system and low-tension interrupter. A primary battery is used only for starting. The engine develops its maximum efficiency at a speed of 2,000 revolutions per minute, but it can be throttled down practically to 300 or 350 revolutions. The radiator is of the fin-tube type, located at the extreme front of the vehicle.

The frame of the chassis is of pressed steel, wood filled. This is mounted on a square-section solid front axle and round solid rear axle. The front wheels are 34 inches in diameter and the rear pair 39 inches, over the tires. Solid rubber tires of American manufacture are fitted all around, the rear pair being of the twin type, to reduce any tendency toward skidding and to increase the life of the tires.

Connection between the engine and transmission system is made by a disk clutch having one steel and two brass disks. The change-speed mechanism is of the selective sliding-gear type, giving four forward speed ratios and one reverse. This is mounted in an aluminium alloy gear case with the two shafts in a vertical plane. The transmission gears and bearings are lubricated with the same oil as the engine cylinders and bearings, which is pumped onto the gears from slots in the case by a worm-geared pump. Drive is by bevel gearing to a bevel gear differential on the countershaft which runs on ball bearings. Instead of using roller chains for final drive to the rear road wheels, the ends of the countershaft are fitted with spur pinions that mesh with internal gears secured to the inside of the wheels. The brake lever is interconnected with the engine throttle, so that the throttle is closed as the brakes are set, thus shutting off the power.

Since the buses were put in operation, they have been equipped with acetylene gas tanks and lamps for interior illumination.

In addition to the De Dion omnibuses that are now in service, the Fifth Avenue Coach Company has contracted for eleven more motor buses, ten of which are to be built in the United States according to specifications prepared by the company's own engineers.

Two hundred head of horses and forty-five stages were displaced by the motor buses now in operation, and were sold by the operating company in the latter part of July. The route covered extends from Washington Square to 90th Street on Fifth Avenue, a distance of more than four miles. The buses run on a five-minute headway, and the schedule allows one hour for the round trip, including stops and a wait of five minutes at each end. This calls for an average speed of ten miles an hour, including stops, whereas the old horse stages were allowed one and one-half hours to cover the route both ways. During the first six months of the new service it was found that the motor buses maintained their schedule, whereas the horse stages often exceeded their time allowance.

The present buses begin running at 7 o'clock A. M. and stop at 11 P. M. Each makes from fourteen to sixteen trips a day, and is manned during that period by two crews of driver and conductor. When all of the seats are filled, no more passengers will be taken on. A single-trip fare of ten cents is charged. If all of the seats in each bus were filled once on each trip, the present service could carry more than 15,000 passengers a day.

When the additional equipment is received, it is the intention of the company to extend the service to several cross-town streets and to routes in Harlem, eventually operating the motor buses from Bleecker Street down town, north to the Harlem River at 155th Street and Central Bridge.

Philadelphia, despite her traditional slowness, was a close second to New York in adopting motor omnibuses. On July 16 last fourteen new double-deck machines, with bodies built after the same design as the New York buses, began running on a seven-minute headway on a five-mile route extending from Spruce Street north on Broad Street to Diamond Street, thence to Fairmount Park. During the first two days, when the Elks' Carnival was in progress, 5,000 passengers rode in the new omnibuses, and on the first Sunday, July 21, 15,000 persons were carried. Since that time the number of machines has been increased to twenty-five, which run on a four-minute headway. They are operated by the Auto Transit Company, which sought for a year to secure a franchise that was granted only last summer. A five-cent fare is charged, and the vehicles run from 5.30 A. M. to midnight.

THE DE DION BUSES USED ON FIFTH AVENUE.

NEW YORK AND PHILADELPHIA MOTOR BUSES.

The Philadelphia omnibuses are of domestic manufacture, being built by the Commercial Truck Company of America, with headquarters in Philadelphia and a large manufacturing plant in a nearby city. All of these vehicles are electric, and they represent the most extensive attempt ever made to utilize the four-wheel-drive principle. The storage battery that supplies the power is carried underneath the body, and each of the four road wheels is driven by an electric motor. Each motor is carried in a fork at the end of the axle, and to provide for steering, the front motors have trunnions on the top and bottom of the motor casing which engage with the yoke ends of the axle, making a swivel joint similar in action to the ordinary steering knuckle. Suitable arms are cast on the motor frame, to which are connected the steering rods. The wheel spindle is a casting of nickel steel, and is bolted to the motor frame. Steering is by hand wheel with screw-type irreversible gear. The axles are of cast nickel steel. Double-reduction gears furnish the drive from the motor armature to the wheel. The motors are manufactured by the Commercial Truck Company and are rated at 22 amperes, 85 volts.

The batteries used consist of forty-two Exide cells, each of which contains 21 M. V. plates of the pasted type. These cells are of sufficient capacity to give a liberal margin of safety for running three round trips, which amount to approximately thirty miles.

With a wheelbase of 10½ feet and tread of 5 feet 10 inches, these electric buses have an overall length of 19 feet. Their weight empty is 11,500 pounds.

A large garage and power house has just been

erected by the Auto Transit Company at Thirty-third and Dauphin Streets for the storage of the vehicles and recharging of their batteries. By means of special machinery the discharged battery can be removed from a vehicle and a freshly-charged battery substituted for it in two or three minutes.

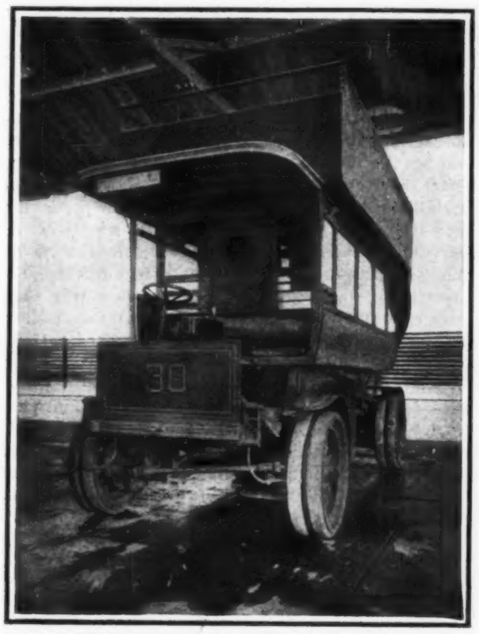
New York and Philadelphia are the only American cities that at present have a regular motor omnibus service, but a company in San Francisco has recently been advertising extensively in the local daily newspapers its proposal to start such a service in that city, and offering to sell some thousands of shares of stock at five cents a share. If the intentions are bona *fide*, this indicates an awakening of interest in the subject on the Pacific coast. The earthquake two years ago gave a powerful impetus to automobiles, especially for utility purposes, in that city, and this fact, together with the succeeding street-car strike, would naturally incline the public there to look with favor upon the introduction of motor omnibuses.

Europe is several years ahead of the United States in the use of motor buses. In London alone more than 900 such vehicles are now being operated by fourteen omnibus companies. These run over regular routes to all important nearby suburbs on regular time schedules. The 800 that were in use in 1906 carried 184,000,000 passengers in the twelve months, which was 4,000,000 more than the London tramroads carried in the same time. Besides the omnibus service in the city, a number of the principal steam railroads of England maintain motor bus lines as "feeders," operating between stations on the railroad and well-populated communities some distance off the line and not otherwise connected with it. Altogether, the railroads of the United Kingdom now operate nearly 270 motor buses and other styles of automobile passenger and freight vehicles. The Great Western Railroad alone has ninety motor buses, which up to June 30 last had run 1,600,000 miles and carried a total of more than 3,500,000 passengers. Some of its routes are twenty miles long. With the exception of a very few steam and electric vehicles, the motor buses in England are driven by gasoline or kerosene engines.

Doubtless the great activity that has prevailed and that still continues in electric railroad construction, the development of motor railroad cars by the steam roads for branch-line and short-haul work, and our notoriously bad public roads, will all tend to retard the development of motor omnibus and stage lines in the United States, yet it is reasonable to believe that we are just now entering upon a new era in passenger transportation. Although the English people have complained long and bitterly against the noise, clumsiness, and foul odors of many of the London buses, there is no doubt that the motor buses in use in New York are much quieter, and in many ways less objectionable than the street cars. Since they do not run on rails, and their self-contained and independent power plants render overhead or underground feed wires or rails unnecessary, it may easily be that as the motor omnibuses are further perfected, they will prove more economical and more convenient than street railroad systems, with their enormously expensive central power houses and installations of tracks and current wires, particularly in small cities and towns where the traffic is not heavy.

RESULTS OF TEST OF AUTOMOBILE TRUCKS BY THE FRENCH WAR DEPARTMENT.

The Automobile Club of France recently made the following report relating to the use of heavy automobiles in the military maneuvers of the southwest army. The cars were used for furnishing the supplies for the troops of the 18th army corps, and the tests were carried out under the general supervision of the Minister of War. A certain number of constructors placed forty machines at the disposition of the army, under conditions which were fixed in advance. As regards the service to be carried out, this consisted in transporting each day to about 72 miles from Bordeaux the supplies which were needed for the troops, representing a mean tonnage of 39. The cars were divided into four sections which were composed so as to be as homogeneous as possible. One section was thus made up entirely of cars having iron tires. Sections 2 and 4 were detailed to carry the supplies on the even-numbered days and return empty on the odd-numbered days so as to be re-loaded and thus be ready to start the next morning. Sections 1 and 3 were to carry the supplies on the odd-numbered days and follow the same plan. Each day about 13 cars were used. The start took place at 5 A. M. The supplying of the troops was carried out from 2 P. M. to 4 or 5 o'clock, after which the cars returned to a distance of 12 or 18 miles to camping points designated in advance. The next day, they reached Bordeaux about noon, and proceeded to the military storehouses in order to be loaded, after which they entered their headquarters where they were cleaned and looked over. The difficulties which were met with at Bordeaux as to the loading of the cars and the consequent late hour at which they came back to the garage, made this service quite laborious for the men and gave a hard strain upon the material. However, there were no important incidents to be noted in the course of the route. A single car, on account of an imperfect adjustment

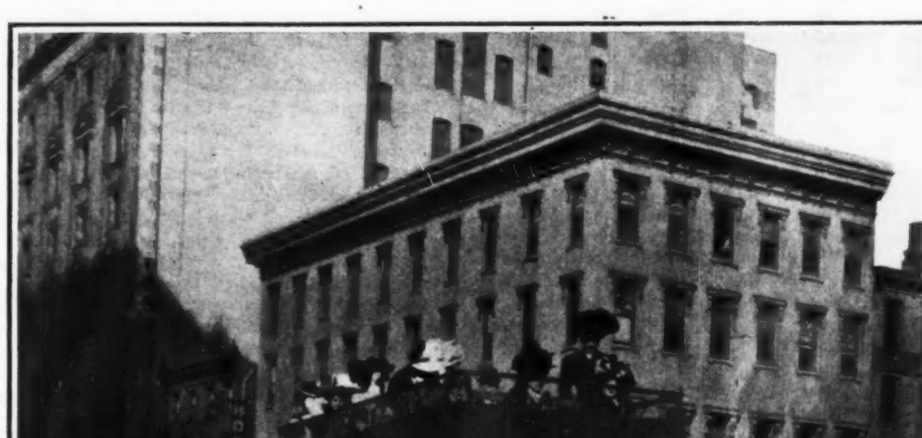


FRONT VIEW OF PHILADELPHIA ELECTRIC BUS, SHOWING METHOD OF HANGING THE MOTORS.

at the start, remained useless for several days. The most serious mishaps were engine troubles from the seizing of the connecting rods on the wrist pins. It seems likely that these accidents were due to exaggerated speeds, which, in spite of the orders, were made by some of the cars. In fact, although running in file, the drivers of the most powerful cars, which normally were at the head of the line, accelerated their speed, and the cars which were in the rear were obliged to exceed their normal speed in order to keep up with them. It will be easy to remedy these disadvantages by forming the sections of the convoys or an entire convoy of cars of the same make and quite uniform, and also by a better training of the men. During the maneuvers it was found that in nearly every case the serious breakdowns were due to an excess of speed, and it is to be hoped that the different constructors will be able to render this impossible by proper mechanical means so as to limit the speed to the kind of work which is demanded from the cars. A lessening of the speed will correspond to a considerable lessening of the expense of maintenance, which at the present time is excessive.

Some interesting experiments as to carrying the wounded were also made during the maneuvers. Several cars, after having carried out the supplying of the troops, were sent to the hospital of Alberac. Here they were furnished with straw and in them the wounded men were placed either sitting or lying. The cars left at once for Bordeaux, which they reached at 6 P. M., after having covered 150 miles without any trouble. The physicians charged with following the experiments declared that they were quite satisfied with the result.

Although many of them were far from being new, the solid rubber tires gave no trouble, and during the whole time of the maneuvers only one had to be replaced owing to a defect in the manufacture. The cars provided with iron tires behaved very well on this occasion, but unfortunately the short duration of the maneuvers will not allow of considering the results as decisive. However, a method which gave excellent results consists in placing rubber tires on the front wheels and iron tires on the rear wheels. A car whose performance deserves great credit for endurance and regularity is one which used iron tires and had shock-dampers in the front and rear. The consumption of fuel during the maneuvers was normal, and if we take account of the fact that one half of the course was made with the cars empty, the cost of the ton-mile net load was about equal to that determined during the trial of heavy cars held in May and June, 1907. However, it is to be noted that during the maneuvers, where the cars of the same power carried about the same loads and made the same stages at like speed, the steam cars had a mean fuel consumption about equal to that of the gasoline cars. To sum up, the Automobile Club expresses the opinion that from a military standpoint the experiment with hauling by motor cars during the maneuvers shows conclusively that mechanical traction can from now on replace animal traction, and its adoption, which will lighten up the army material considerably, will allow of easily solving the complicated problem of supplies and evacuation of troops in the field. From a general standpoint, it is seen that the manufacturers have established heavy cars which will render the greatest service in commerce and industry, and they are at present practical and often economical. It may be mentioned that the cars were of the leading French makes such as the De Dion, Mors, Panhard, Lorraine-Dietrich, Darracq, Serpollet (steam), etc., ranging from 20 to 40 horse-power, and carrying a net load of two to five tons. Altogether, there were eight cars which belong to the War Department.



ONE OF THE DOUBLE-DECK ELECTRIC OMNIBUSES NOW IN SERVICE IN PHILADELPHIA.

NEW YORK AND PHILADELPHIA MOTOR BUSES.

Correspondence.

THE RELATION OF THE GOVERNMENT TO THE DEVELOPMENT OF SUBMARINE VESSELS.—II.*

[IN publishing the following letter from Mr. R. G. Skerrett, the Editor disclaims all responsibility for the statements made.]

ARE THE AMERICAN PEOPLE IN ANY WAY EXCLUSIVELY SECURED FOR THE HEAVY DRAIN UPON THEIR PURSE FOR THIS EXPERIMENTAL WORK?

Early in January of 1901, the John P. Holland Torpedo Boat Company addressed the chairman of the Committee on Naval Affairs of the House of Representatives regarding additional legislation in the following manner:

"The company has spent about $1,000,000 in developing the submarine boat, an invention that is of no benefit commercially to any one, and can only be used in the defense of the harbors and coasts of the United States. It has a trained body of engineers, electricians, officers and crew, that have for years been in the service of the company at the company's expense studying and perfecting work that *is only useful to the government of the United States.*"

Rear-Admiral George W. Melville, U.S.N., in his testimony before the Naval Committee of the House of Representatives, stated that the five Holland submarines originally ordered by the British Admiralty were contracted for in the fall of 1900—*prior to the date of the foregoing letter.*

A considerable measure of further enlightenment regarding the degree of patriotism of this company can be gathered from the writings of Sir William H. White, K.C.B., formerly Chief Constructor of the British Navy. Sir William had this to say in one of his contributions to the London Times in 1905:

"It may be worth stating, although the facts should be obvious and the statement involves no breach of official confidence, that everything done in France and the United States from 1895 onward in connection with submarine construction was thoroughly well known and carefully considered by the Admiralty at the time. French experience, of course, could not be made available, and it was a fortunate circumstance that at the critical moment the Holland Company came forward, placing the British navy in a position to benefit by their experience and information.

"The Admiralty thus insured success in preliminary orders for submarine vessels; because they acquired the accumulated experience of the Holland Company and of Mr. Holland himself, *with a guarantee that further improvements made in the United States during the continuance of the agreement should be placed at their disposal through Messrs. Vickers.*"

HAVE ALL CREDITABLE SOURCES BEEN DRAWN UPON IN DEVELOPING THE SUBMARINE VESSELS FOR THE UNITED STATES NAVY?

Up to and inclusive of 1901, the Navy Department had not asked Congress to legislate for more vessels of that sort. The acts of 1896, 1899, and 1900 were the result of promotive influences exerted upon Congress. The Navy Department was waiting to see how the original "Plunger," contracted for in 1895, would perform when finished. In 1901, while the navy had proof of the Holland Company's skill only in the very modest performance of the little "Holland," the promoters of that boat were busy in Congress endeavoring to secure further legislation for a large number of vessels of that particular type. About this time the attention of the Navy Department was called to the possibilities of another type of submarine vessel, and so impressed were the officials of the Department with the merits of this new design—then having under advisement a letter from the chairman of the Committee on Naval Affairs of the House of Representatives regarding the advisability of ordering more Holland boats—that the board of naval officers responded in part as follows:

"Should Congress see fit to authorize any more submarine boats, the Board is of the opinion that *no special type should be specified*, but that the Secretary of the Navy should be given discretion to contract for such boats as in his judgment are likely to prove the most efficient and best suited for naval purposes, *thus opening up competition and giving other inventors a chance.*"

This attitude on the part of the Department and the advent of another type of boat prevented legislation for the Holland Company in 1901.

The promoters of the new type of boat, the Lake Torpedo Boat Company, of Bridgeport, Conn., confided in the verbal assurances of departmental officials that should the company build a boat at its own expense and submit it to the government for test, the Navy Department would be only too glad to give it a careful and serious examination with a view to possible purpose; this company of enterprising men —so much faith had it in Mr. Simon Lake's boat—went down into its pocket and began the construction of a vessel representing an outlay of probably $200,000. There was no helping hand from the government in this case. On the 1st of November, 1902, the boat was launched, and within eighteen months from the date her keel was laid she was ready and running—an example of successful expedition unequaled by the record of any of the submarines yet built for the United States navy. Early in 1903 the boat was ready, and the Navy Department was so advised.

* Concluded from SUPPLEMENT No. 1681, page 181.

The Holland Company was not disposed to allow this new rival to walk into the field of submarine construction and to secure recognition without making a stiff fight to retain exclusive patronage. Accordingly, in 1902 the Holland Company sought to secure an appropriation for additional boats of its own particular type. Its efforts brought matters to a climax in Congress and resulted in hearings before the Naval Committee that are full of enlightening details. No appropriation was passed for submarines during that session—the testimony before the Naval Committees being distinctly discouraging to any further partisan legislation. The Chief Constructor, then Mr. Francis T. Bowles, going on record as opposed to appropriating money for any particular type, further recommended that not more than one boat should be ordered from any competing builder of submarine vessels; Mr. Bowles's whole contention being inspired by what he considered the best interests of the government and the advancement of the art.

In March of 1903, Congress passed a bill appropriating $500,000, and authorized the Secretary of the Navy to purchase subsurface or submarine boats after due competitive tests with the submarines then in the navy—the "Adder" and "Moccasin," built by the Holland Company, having been finished and placed in commission at Newport, R. I.

Such was the state of affairs when the Lake Torpedo Boat Company tendered its boat to the Navy Department, under date of June 1, 1903, for competitive test, agreeably to the law, with the boats then in the navy, and in commission at Newport. The Holland Company objected to this on the score that it had overhauled and modified its former test boat, the "Fulton," and requested the indulgence of a delay until some time in September, when it hoped to have the "Fulton" ready for official examination. There were successive delays, and the "Fulton" was not actually submitted for test until the latter part of May of 1904. The Lake Torpedo Boat Company, which had not had the benefit of governmental aid and which was bearing all the while a burden of expense due to postponement of trials, grew impatient over these delays, and again besought the Department to allow the competitive trials to proceed with one of the rival type of the "Adder" class. In response to the insistence of the Lake Torpedo Boat Company, the matter was referred to Capt. C. J. Train, U.S.N., senior member of the Board of Inspection and Survey, who had learned of the performances of the "Protector." Congressman E. J. Hill, of Connecticut, is responsible for our knowledge of what took place between the Secretary of the Navy and Capt. Train. Mr. Hill said to the Secretary and Capt. Train:

"Gentlemen, I ask you now to carry out the spirit of the legislation of last year and put a government boat in this competition; you have six of them. Capt. Train replied to me: 'It is absolutely useless; *I am ready to admit now that the 'Protector' outclasses anything which the government has.*' "

The Holland Company began with the "Plunger," and as Mr. Creecy has said it had nothing to show but plans. That vessel was a failure. The Holland Company next built the "Holland," which represented "the inventor's most advanced ideas," and we have already seen how far she came from realizing the achievements promised for the "Plunger." The government bought the Holland and ordered seven larger boats of the "Adder" class, paying for the Holland Company's experimenting by a substantial encouragement amounting to $1,190,000. On the other hand, at its own expense, the Lake Torpedo Boat Company built the "Protector," and in its first vessel surpassed, so Capt. Train admitted, anything yet realized by its business rival. Growing utterly weary of continual postponements and failure to have its boat tried out in the manner provided for by the law of 1903, this enterprising firm sold the "Protector" to Russia, and upon the performance of that craft in the Baltic five more of the same sort were ordered at once and a short while afterward—the vessel continuing to win official approval—still more of far greater displacement and military possibilities were contracted for.

In 1904 Congress again offered encouragement to open competition, and raised the appropriation of the year preceding by $350,000—making the total sum available $850,000.

It was not until after it became known that the "Protector" was dismantled and would probably not be again ready for trial before the fall of 1904—she was really being got ready for shipment abroad—that the Holland Company notified the Navy Department that it would submit the "Fulton" for test some time in May. Accordingly, the "Fulton" was tried out at Newport during the last days of May and the early part of June; and while her speed performances showed her to be inferior to her sister boats of the "Adder" class, still, because of certain minor modifications, the board reported her to be on the whole an improvement upon her classmates; and while not recommending the purchase of the "Fulton," it did recommend the ordering of larger boats which were to be improvements upon this latter vessel. These new boats were to be experimental and the government was to pay the cost.

As soon as the "Protector" had been sold to Russia, the Lake Torpedo Boat Company began the construction of an improved "Protector," which it notified the Department would be duly submitted for official test agreeably to the act of 1904. Here again there was trouble.

Although the "Protector" had been officially acknowledged by Capt. Train to be superior to the "Adder" class, and there was every reason to warrant the belief that the later Lake boat would improve upon her predecessor, still the Navy Department showed no real disposition to give this second evidence of enterprise the reasonable indulgence in time that an undertaking of this sort warranted—although the rival company had been given eleven months in which to perfect its boat after the Lake Company had pronounced the "Protector" ready.

As we have seen, all of the boats of the "Adder" class were many months behind the promised dates of their delivery to the government, yet this second boat offered by the Lake Torpedo Boat Company was built, launched, and running within seven months from the day her keel was laid. This vessel, commonly known as the "Simon Lake X," was built at Newport News, Va. The Department declined to test the vessel in the nearby waters of the Chesapeake, and insisted that the boat should be tried in the waters of Narragansett Bay, which was then full of ice and would probably not permit of the proper trial of the vessel before some time in April—meaning a delay of two months or more. Again, the Lake Company had a ready market for its vessel, and the boat was sold to Russia without further delay.

The Holland interests secured orders for four boats under the combined appropriations of 1903 and 1904; and one of these vessels, the "Octopus"—the largest and best—is still in her builders' hands because of a mechanical breakdown during the time of her acceptance trials last summer.

In 1906 Congress again appropriated for submarine boats and provided $500,000 for that purpose—limiting the time in which boats could be submitted under that law to a period not exceeding nine months from the date of the passage of the act. Agreeably to that law, the Lake Torpedo Boat Company notified the Navy Department that it would submit for trial a third boat, the "Lake," which had been built by this concern at its own expense. The Department then appointed a board for the purpose of prescribing a general programme for competitive tests and purchase agreeably to the provisions of the act of 1906. This board, for some reason that has never been explained—even though the Department had been notified of the readiness of the "Lake"—set February 18, 1907, as the time and Narragansett Bay as the place for trials, regretting incidentally that the tests must be completed by March 29, 1907, because the climate in Narragansett Bay in February is very severe.

In March of 1907, another act was passed extending the time of test period, and authorizing a total appropriation of $3,000,000. In this case, however, the act was passed in such form that the wording became virtually partisan legislation. The "Octopus," the biggest of the Holland boats then under construction at the government's expense, and nearing her tardy completion, was made the standard, and the act read as follows:

"No part of this appropriation to be expended for any boat that does not in such test prove to be equal in the judgment of the Secretary of the Navy to the best boat now owned by the United States or under contract therefor, and no penalties under this limitation shall be imposed by reason of any delay in the delivery of said boat due to the submission or participation in the comparative trials aforesaid."

This act completely changed the spirit of the law of 1906 under which the Lake Company had submitted the "Lake" to the Navy Department for test agreeably to that company's letter of July, 1906. The "Lake" had not been built to meet any specific requirements and naturally, being the third boat the company had built at its own expense for governmental test, the Lake firm did not strive for exceptional speed, which always represents a corresponding increase in cost. She was designed, however, to be a thoroughly efficient instrument of war and a valuable addition to any naval service.

Apart from being guaranteed against the imposition of accrued penalties due to delayed construction of

the "Octopus," the Electric Boat Company was permitted to enter in this contest a craft for which the United States had borne the cost of experimental development; and to win, all that the Electric Boat Company had to do, was to make the "Octopus" live up to the contract requirements under which she had been ordered. Had the standard of performance been made equal to results secured in Europe upon a corresponding displacement, the Electric Boat Company would have been confronted with a task that would not have placed the "Octopus" in the same favorable light.

Naturally, under the circumstances, the "Lake" could not be expected to make a superior showing; and because of the restrictive wording of the law the major part of the appropriation went to the Electric Boat Company and seven boats were ordered from that concern. The Secretary of the Navy, however, was fully pursuaded that the boats of the "Lake" type possessed distinct merits, and he believed that that company could produce vessels of high military value; but he felt obliged to defer to the Attorney-General for an opinion regarding the Department's power to enter into a contract with the Lake firm in view of the wording of the law of 1907. The Attorney-General decided that the Department could so contract with that company. Secretary Metcalf, therefore, has ordered a boat of the Lake type of 500 tons displacement, but not one penny is to be paid until the vessel has been finished and tried and formally accepted by the Navy Department. Once again the Lake firm is obliged to foot this bill and to embark upon a fourth enterprising venture to secure governmental recognition. This is entirely contrary to the character of the contracts with the Electric Boat Company, which receives regular installments from the government as the work on its vessels proceeds—the question of the meeting of the contract terms being of course undecided until the vessels have been actually tried.

If the vessels of the Holland type are all that is claimed for them, there should be no need of so wording the present appropriation bill that the field should be narrowed down to boats of their particular type: their merit would speak for itself.

The inventive mind of America is too fertile to be hedged in by legislative prescription, and it is only fair to native genius and to national security that our money should be allowed to produce for us the best instrument or means of seaboard defense that the state of the art can provide. No sane student of naval affairs now denies recognition to submarine craft, but he realizes nevertheless that the art is essentially a new one, that it is experimental, and that developments and changes are likely to be both rapid and radical. Let Congress recognize these facts and keep the field open to everyone. ROBERT G. SKERRETT.

15 William Street, New York, March 12, 1908.

OUR COAL BRIQUETTING INDUSTRY.—II.*

A COMPLETE REVIEW OF AMERICAN DEVELOPMENT IN A NEW ENTERPRISE.

BY EDWARD W. PARKER.

Concluded from Supplement No. 1681, page 180.

CALIFORNIA.

THE manufacture of briquettes has shown more actual progress in California than in any other State of the Union. This has been brought about through efforts to improve the fuel quality of the rather low-grade California sub-bituminous coals, and has been encouraged by the high prices of the better grades of bituminous coal or anthracite brought into the State from Washington, the Rocky Mountains, and the Eastern States, or imported from British Columbia, England, Australia, and Japan. It has also been encouraged by the abundance of cheap asphaltic pitch, which can be obtained from California petroleum and which not only serves excellently as a binder, but adds to the calorific value of the briquetted fuel.

The first plant to be put into successful operation in California was one built at Stockton by the San Francisco and San Joaquin Coal Company. The plant was completed in 1901, and when running at full capacity could produce 125 tons of briquettes per day. The fuel used was sub-bituminous coal from the Tesla mine, in Alameda County. The plant was, unfortunately, destroyed by fire in 1905 and has not been rebuilt. It is stated that the plans of the company were to rebuild the plant at San Francisco, but these were upset by the earthquake and fire which destroyed a large part of that city in April, 1906. A complete description of the Stockton plant, by the designer of the presses, Robert Schorr, of San Francisco, was published in the Engineering and Mining Journal August 18, 1904. The briquettes produced at this plant were round, convex lenses or "boulets," which weighed from six to eight ounces.

The Western Fuel Company, of Oakland, completed early in 1905 a briquetting plant, also designed by Mr. Schorr.† In mechanical construction this plant differs materially from the one destroyed by fire at Stockton. The shape of the briquettes is cubical instead of "boulet." The advantage claimed for the cubical shape is that the briquettes ignite more readily, though it is admitted that there is more waste in handling.

The capacity of this plant is 480 briquettes per minute or 8½ tons per hour. The fuel used is coal-yard screenings from lignites, anthracite, and sub-bituminous coals, with about 7½ per cent of asphaltic pitch. This pitch is obtained by the distillation of California crude petroleum. The temperature of the still for the production of pitch of the proper grade is about 600 deg. F. Some difficulty has been experienced in obtaining suitable pitch on account of the tendency of the refineries to "rush the stills," their aim being the production of refined oils rather than pitch. An excellent asphaltic pitch is obtained by keeping the stills at a temperature of 500 deg. F. and using a vacuum to force the distillation. Grade "D," the quality best adapted for the purpose, is fairly hard up to 60 deg. F., but begins to soften above that temperature. It becomes liquid at 250 deg. F., and has a specific gravity of 1.05 to 1.1.

Before the earthquake the Western Fuel Company paid $10.50 per ton for the ordinary pitch "D" delivered at its plant, and a properly and carefully prepared pitch was worth from $12 to $13. Owing to the enormous building activity in San Francisco since the earthquake the demand for asphaltum for roofing materials has increased by leaps and bounds. Consequently there is a great scarcity and the price per ton ranges now from $14 to $20. This scarcity necessitated many shutdowns of the plant at Oakland, and for that reason the company is negotiating for the importation of coal-tar pitch from the East and from Europe. As three new refineries are contemplated, conditions may gradually return to their normal state.

All of the coal purchased and used by the Western Fuel Company is brought in ships and is unloaded by electric hoists into receiving bins. When drawn from the storage bins it is screened, all material that passes through the perforations dropping into auxiliary bins from which it is fed into a Williams crusher. The disintegrated coal from the crusher is elevated into the iron hopper of an automatic feeder that feeds into the coal heater. The heated coal enters the mixer, where it meets the binder. The mixer, the binder distribution, and the tempering of the mixture embody some novel features.

The prepared material is conveyed into the feed hopper of a Schorr press, style "A," which is belted for six revolutions per minute. At that speed 480 briquettes of 9½ ounces in weight are discharged per minute, or more than 17,000 pounds per hour. The briquettes are rectangular in shape, with rounded corners, and uniform in size, 2¾ by 2½ by 1⅞ inches, and are branded with a "W." They have a specific gravity of 1.22.

All wearing parts of the press are lined with phosphor bronze, and are thoroughly lubricated under an air pressure of 40 pounds to the square inch. Oil is also atomized and sprayed into the molds and upon the plungers.

The briquettes drop upon a short conveyor that delivers them to another one located outside the building. At this point they are sacked for the local market or taken to the top of the storage bunkers, where they are discharged into cars or distributed into the bunker compartments. The average output is 64 long tons per shift of eight hours. Four men are employed, one of them getting $4, one $2, one $3, and one $2.75 per day, which makes about 20 cents per ton of briquettes. By running twenty-four hours a day over 200 tons could be made, which would reduce the labor item to about 14½ cents per ton. This can be further cut down by speeding the press up to seven revolutions per minute. This would produce 560 briquettes per minute, or 20,000 pounds of 9½-ounce briquettes per hour. With a forced feed attachment a further increase in speed may be possible.

Since the foregoing was written wages have been increased considerably, most of the men getting $3.50 per shift, working through the lunch hour.

The present pressure arrangement was tested up to 48,000 pounds, exerted on two 2½ by 2¾-inch surfaces, making over 3,700 pounds per square inch. The adjustment is placed to give about 2,900 pounds, which is ample and makes a better burning briquette than when a greater pressure is used. The press is figured for a maximum pressure of 6,000 pounds.

The following description of the briquetting press is taken in the main from an article by Mr. Schorr:*

Two soleplates with heavy bearings are arranged to carry a stationary steel shaft, on which a large spur wheel is revolving, driven by means of gearing, countershaft, and friction-clutch pulley. The spur-wheel rim is made integral with a mold ring which has a series of holes and sliding plungers (pistons) therein. The pistons are under the continuous control of cams, which are supported by heavy shields. The pistons are released from the cam way only when the final pressure is applied, and this is done by a large wheel with steel tire, pivoted in two levers. This wheel is pressed against the piston heads by means of an adjustable spring which permits a perfect regulation of pressure up to 4,000 pounds per square inch. After leaving the pressure wheel—that is, after the briquette is made—the plungers are gradually forced forward to eject the briquettes, which drop upon a vibrating discharge chute. The pistons are then gradually withdrawn and in passing the feed box the cavities become filled with the mixture of coal and pitch. At the end of this feed box all surplus material is scraped off by a steel plate. After passing the scraper plate the pistons are gradually forced in, pressing the material against the resistance block, which is supported by the main shaft. This pressure is effected by a cast-iron stand with phosphor-bronze liner. When the pistons are about half an inch from their terminal they strike against the rocking pressure wheel and are forced home. In this way the briquettes are made and the play repeats itself with every revolution.

The machine is entirely self-contained, and it is claimed that there is no possibility of its getting wrecked by overfeed or obstruction. It is also claimed that as the pressure is applied slowly and gradually this type of press permits briquetting mixtures containing 13 to 14 per cent of moisture, and that this is an advantage not possessed by intermittently acting presses. Up to the present time two styles have been made—one with two rows of 2-inch cylindrical molds and the other with two rows of 2½ by 2¾-inch rectangular shapes with rounded corners. There is no difficulty in making other shapes and heavier briquettes. A simple arrangement permits working with half the capacity when desired. No complications are presented if it is desired to have more than two rows of molds, and the press can be built for a much larger capacity. On the other hand, should the market for briquettes be lessened for some months in the year, the capacity can be cut down without requiring any change in speed or other alterations.

From 80 to 120 briquettes are made for each revolution, the number depending on the size and shape of the briquettes. These factors govern also the capacity, which ranges from 6 to 24½ tons per hour.

Mr. Schorr states that all wearing parts of the machine can be quickly and cheaply replaced. The lubricating is done by an air compressor and oil atomizer.

The press is especially adapted for the manufacture of small briquettes, and the advantages of such in preference to large blocks are obvious. Small briquettes can be readily shoveled into furnaces, whereas the large ones have first to be broken up, thus causing labor, waste, and dust.

A briquetting plant of an entirely different type, designed by Charles R. Allen, was built and put into operation by him during 1905 at Pittsburg, at the junction of San Joaquin and Sacramento rivers, about fifty miles from San Francisco. This plant as originally projected was intended to utilize the sub-bituminous coal produced by the Pittsburg Coal Mining Company at Somersville, but the enormous increase in the production of oil in California has had so demoralizing an effect on the coal trade generally that there has been little or no market for the coal during the last two years and the mines have been shut down. The

* From a United States Geological Survey Bulletin.

† See Engineering and Mining Journal, September 9, 1905.

* See Engineering and Mining Journal, October [illegible], 1905.

material used has been screenings obtained from the coal yards of San Francisco, the binder here, as at other plants in the State, being asphaltic pitch. The screenings are sold at less than the cost of mining coal, and as long as the supply of this material is available at such prices it will continue to be used.

The methods of preparing the briquetting mixture differ somewhat from those used at other plants, in that the binder, together with the fuel, is passed through the retorts under a high degree of heat. This it is claimed insures an intimate and thorough mixture, each particle of fuel being impregnated with the binder. This treatment it is asserted prevents the binder from being consumed before the coal is ignited, which is apt to be the case, particularly with sub-bituminous coal, if the mixing is merely superficial. Mr. Allen claims that in his process the nature of the fuel is changed so that the sub-bituminous coal partakes of the character of bituminous coal, the briquettes remaining firm and hard until entirely consumed. He claims also that the process possesses as much novelty and value as the press.

The compressing machine consists of two non-concentric rings horizontally placed one within the other, the periphery of the smaller one being corrugated, or scalloped, and engaging with similar corrugations in the inside of the larger ring. The briquetting mixture is fed into a hopper one-fourth of a revolution of the smaller ring from the point of compression, and the amount of pressure is regulated by the distance of the feed from the point of compression; that is to say, the hopper may be placed farther away if a greater pressure is desired, or nearer if the pressure is to be reduced. Relief from an excess of pressure is provided for by two heavy spiral springs on the outer bearings and two over the upper pressure plate, the lower pressure plate being fixed. The machine has been operated without using any of the springs, with the result that when there was a surplus of feed the operating belt was thrown off through the choking of the machine.

Mr. Allen's invention is United States patent No. 851,007. The briquettes as now made are approximately cylindrical in shape, with flat ends. They weigh from 8 to 10 ounces each and have a specific gravity of 1.14. It is Mr. Allen's intention to reduce the size of the briquette and change its shape by having the smaller ring of the press made without corrugations. This will be done in order to meet the demand for a briquette better adapted for domestic use.

The plant is at present turning out about five tons of briquettes per hour, at a moderate running speed. With a smaller briquette the production per hour would be decreased with the same speed, but by increasing the speed the same production could be had.

The Standard Coal Briquetting Company, of Oakland, constructed in 1905 a plant designed by a Mr. Crawford. An accident to the press shortly after being put in operation practically wrecked it and the enterprise was unsuccessful.

Another plant, beginning operations in 1905, used a small press of the plunger type, designed by A. Demetrak and built by the American Briquetting Company (afterward reorganized as the Ajax Briquetting Company), of San Francisco. It was destroyed by the earthquake and fire of April, 1906, and has not been rebuilt. The plant had a capacity of about 15 tons a day, using sub-bituminous coal from Coos Bay, Oregon, sometimes mixed with coal-yard screenings and asphaltic pitch.

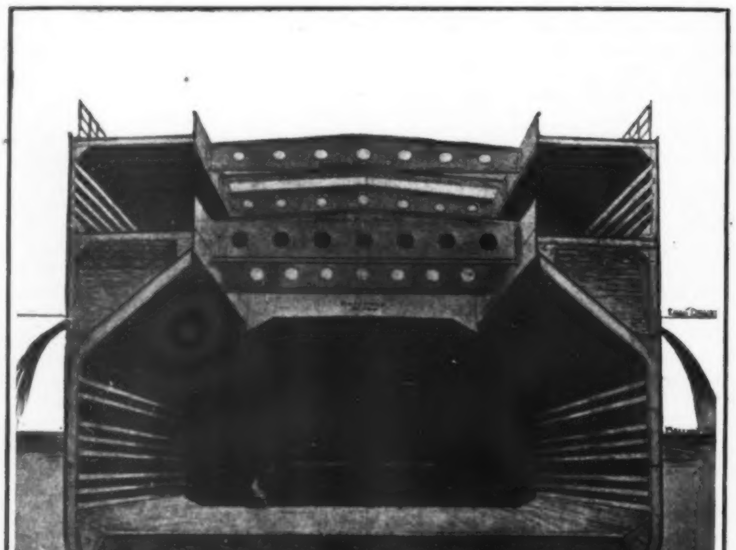
The United States Briquette Company, of Stege, Contra Costa County, has undertaken the manufacture of briquettes from a mixture of peat and California crude petroleum. This plant had not been completed at the time of writing this report, but some briquettes made of the mixture in an experimental way are interesting productions. They give promise of a method of using California oil as a domestic fuel, the peat on account of its spongy character acting as a carrying vehicle for the oil and at the same time performing duty as fuel. The briquettes are cubical in shape and of attractive appearance. They weigh about 10 ounces and have a specific gravity of 1.3. It is claimed that they are as well adapted for steam raising as for domestic purposes, giving an intense heat under forced draft and burning freely under ordinary draft; that they can be handled without waste from breakage, and that they leave a minimum amount of ash and do not clinker.

(To be continued.)

RECENT FREIGHT STEAMSHIP DESIGNS.

NEW WAYS OF BUILDING STEAMERS FOR SPECIAL PURPOSES.

ONE interesting outcome among British shipbuilders of the increase in the dimensions and weights of machinery, the component parts of which often attain bulky proportions somewhat difficult to handle and stow away in the holds of vessels for transport, has been the designing of special classes of craft for such work, and which are equally applicable to the transportation of mineral ore. In such boats the main object is to secure as wide and as large a clear space as possible in the holds without any internal supporting pillars or strengthening structural members of the vessel's hull.



SECTION OF THE "ECHUNGA," SHOWING THE EFFECTIVE SIMPLICITY OF HER HOLD DESIGN.

HOLD OF A NORWEGIAN STEAMER DESIGNED FOR CARRYING ORE ON THE PATENT "TRUNK" SYSTEM.

RECENT DEVELOPMENTS IN FREIGHT STEAMSHIP DESIGN.

Probably the most interesting development in this direction is the cantilever framed topside tank, which during the past few years has come so extensively into vogue among freight-carrying steamship lines for the transit of ore, cattle, and cumbersome articles which cannot be conveniently handled with the ordinary type of steamer. The largest vessel ever carried out upon these lines, the "Echunga," to the order of the Adelaide Steamship Company, Ltd., has recently been completed for service between Europe and Australasia. This company does a large trade in coal, ore, and cattle transportation, and this vessel was especially designed for this traffic.

The vessel, which has been constructed under a number of patents, is 405 feet in length by 56 feet beam and 26 feet 8 inches molded depth. It will carry about 8,400 tons on the assigned loadline, with a capacity for over 11,000 tons measurement of cargo.

The "Echunga" ranks among the most effectively equipped freight boats afloat. In the first place, she will carry a dead weight of about 3¾ times her net register tonnage, the latter being 2,245 tons and the former 8,400 tons on a draft of 23 feet 9 inches. Her water-ballast tanks are of 3,200 tons capacity, of which 1,350 tons is carried in the topside tanks, and the remainder in the double bottom and peaks. When the vessel sails in ballast the propeller is immersed and is consequently in extra trim for speed results and good seagoing qualities. The hatchways are all 30 feet wide, while the largest is 42 feet long. The boat is a perfect self-trimmer, and the holds are absolutely clear of any obstruction such as beams, webs, and pillars. Unusual facilities for handling the freight are provided, there being no less than 14 derricks and 8 gaffs having 25 extra powerful steam winches. By this arrangement it is possible for 32 gangs of coal heavers to discharge her 8,400 tons of coal in 48 hours.

The shelter deck and 'tween-decks are especially arranged for cattle, horses, or troops. Heavy stanchions are fitted around the shelter deck at suitable distances apart to which wood framing for the exposed cattle pens can be attached.

Triple-expansion engines placed right aft supply the propelling power. These have cylinders 27½ inches, 44 inches, and 77 inches diameter by 48 inches stroke. Steam is raised in four large single-ended boilers, the working pressure being 180 pounds. Upon the trial trip the boat attained a speed of 12.75 knots, which was considered completely satisfactory by her owners.

Another freighter of somewhat different design has recently been completed for the Norwegian ore-carrying trade upon the patent "trunk" system, in which one long clear hold is provided and the engines placed aft. The hold of this boat is 256 feet in length, and though essentially intended for carrying ore and coal, is equally adaptable to dead-weight and bulk cargoes.

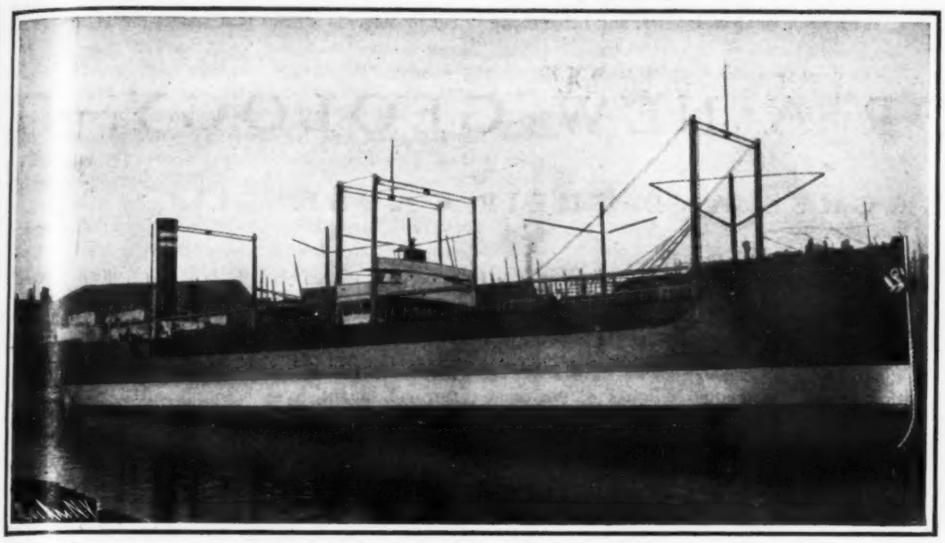
The vessel is 372 feet in length by 52 feet 6 inches beam by 25 feet deep; carries 7,550 tons dead weight loaded to her summer loadline, and has a capacity of about 10,000 tons measurement. The hold, which extends for about two-thirds the total length of the boat, is served through two hatches, each measuring 102 feet in length by 26 feet wide.

Over 2,000 tons of water ballast are carried, [illegible] tons of which is situated above the main deck in the trunk ballast tanks well above the center of gravity of the vessel, thus insuring a steady ship and a good draft in ballast trim. The two pumps for charging and discharging the ballast tanks are capable of dealing with about 2,000 tons of water ballast in six hours.

The boat is a self-trimmer, and only such portable center-line pillars are fitted as are necessary to secure the shifting boards when these are required. There

are no quarter-line pillars. For the convenience of loading and unloading the vessel is fitted with eight large derrick masts and eight derricks with nine steam winches.

The captain and officers' accommodation is placed in the poop, and the engineers' in houses on the poop.



A STEAMSHIP DESIGNED FOR THE CARRYING OF IRON ORE.

The chart house and navigating bridge is built on a narrow platform spanning the hold amidships.

Triple-expansion engines are fitted, having cylinders of 26 inches, 42½ inches, and 69½ inches diameter respectively by 45 inches stroke, and steam is raised in two boilers to 180 pounds working pressure. In addition there is also a multitubular boiler supplying steam at 100 pounds pressure, evaporator, feed heater, and atmospheric ash hoist. In the trial trip a speed of approximately 11 knots was attained on the measured mile. Among the shipbuilders on the north coast of England, which is the center of the British freight steamship industry, a healthy rivalry exists in the designing of vessels with the largest clear holds and hatches, and there are quite a dozen firms engaged in the building of such vessels upon individual lines, of which the two described in this article are the most recent examples.

NEW AIRSHIP BUILT BY M. JULLIOT.

After having finished his work upon the design and construction of the airships "Lebaudy" and "Patrie," which are of a type specially fitted for use in connection with fortified posts, M. Julliot took up the question of a somewhat different type of airship which should be specially used for the army in its different operations. The military airship is to be more powerful as well as more rapid than the type of fortress balloon, and the French Minister of War, seeing the great value of such an airship, requested M. Julliot to proceed with drawing up the plans for the same. At the present time these are entirely finished, and they are now undergoing an examination by the special commission which the War Department appointed for the purpose. We are able to give some of the leading dimensions of the new type of airship. Length, 100 meters (328 feet); maximum diameter, 11.50 meters (37.7 feet), which gives a length equal to 8.69 diameters and is quite well suited for high speeds. Volume of balloon 7,000 to 8,000 cubic meters (247,198 to 282,512 cubic feet).

As in the airship "Patrie," the balloon covering will be made of rubber-coated fabric, but the thickness will be proportioned so as to meet the increase of interior pressure which is caused by the increase in the volume of the balloon and also by the necessity of keeping the permanence of the form in spite of a higher speed. This rigidity of the envelope will be obtained as in all the French types of balloon by the use of a ballonette which is supplied by an air fan of large output. The large oval platform, the fixed and movable planes of the airship, the balancing while *en route*, and the steering method which characterize the type Lebaudy-Patrie, are kept here in their general arrangement. Nevertheless, there will be added two propellers mounted on vertical shafts which are designed to aid in the stability of the airship as regards the altitude without needing the use of ballast in all cases. The motor-propeller system will comprise two pairs of propellers for driving (each pair of screws being disposed as in the "Patrie"). The propellers can be placed, one pair in the front of the car and one pair in the rear. As before, the propellers will be of the high-speed type. Each pair will be operated by a 120-horse-power motor and thus there will be two independent groups of motor and propeller. This will be of great use in case of a mishap to the motor, such as caused the loss of the "Patrie," inasmuch as the airship can now be driven by the use of the second motor and propeller. As regards the motors to be used for the airship, these will be the motors which were mounted on the gasoline launch Panhard-Tellier; this craft made a fine series of races during the last season. Each of the motors is of the 4-cycle Panhard-Levassor type and is rated at 120 horse-power, giving the airship a total of 240 horse-power. The main points for the motor are: bore, 185 millimeters (4.5 inches); stroke, 175 (4.4 inches); speed, 850 revolutions per minute. The general size including the flywheel is 0.75 meter (2.5 feet) width, 1.30 meters (4.3 feet) length, and 1.15 meters (4.0 feet) height over all. The weight of the motor alone, including the water jacket of sheet copper (without flywheel, piping, carbureter and accessories which can be lightened up) is 280 kilogrammes (620 pounds). In the Panhard-Tellier auto-boat the motors were placed side by side, and perhaps this arrangement will be retained here.

The speed which the new airship will probably reach is 35 miles an hour. The net load which it can transport at this speed, including men, ballast, gasoline, projectiles, etc., will give the present airship a radius of action and an offensive power which will greatly exceed the performance of any French airship which has been built up to the present. Moreover, special arrangements have been designed so as to assure the security of the balloon as much as possible should it alight in the open country. But a type of collapsible balloon shed will soon be designed, and it will form part of the material of the troops when in campaign. The extent of the radius of action will be such that in most cases the airship can reach one of the fixed shelters. The latter will be erected in the near future, inasmuch as the development of the aerial fleet requires their use. In order to compare the above dimensions with those of the "Patrie," we will recall the latter so as to show that it is a veritable pigmy beside a giant. The "Patrie" has not much more than half the length, or 62 meters (204 feet) and a less diameter, 10.30 meters (34 feet), giving a proportion of 5.90 diameters for the length. It uses a motor of 70 horse-power. The new airship will therefore have more than three times the power.

It may appear strange that M. Julliot is taking up the construction of one of these great airships of which he was thought to be the opponent. This is not exact, however, since in 1904 at his lecture before the Société des Ingenieurs Civils he terminated the discussion in giving as his opinion that the future was reserved for the large balloons. But this does not imply that the average size such as the airships "Lebaudy" and "Patrie" are to be abandoned. These types are perfectly appropriate for the rôle which they are to fill, and they have given ample proof of their good performance. Therefore the class will be continued in order to add further units of this kind to the army outfit. In May next the new airship "République," which is built identical with the "Patrie," will be entirely finished. After this the next balloon of the class, "Liberté," which is of slightly larger and more powerful build, will be put in construction, and it is expected to have it finished in 1908. As will be seen, without mentioning different types of airship which may be proposed by other constructors, the French aerial fleet is gradually taking shape, and already the units are being differently designed according to the service which will be asked of them.

TESTS OF VEHICLE AND IMPLEMENT WOODS.

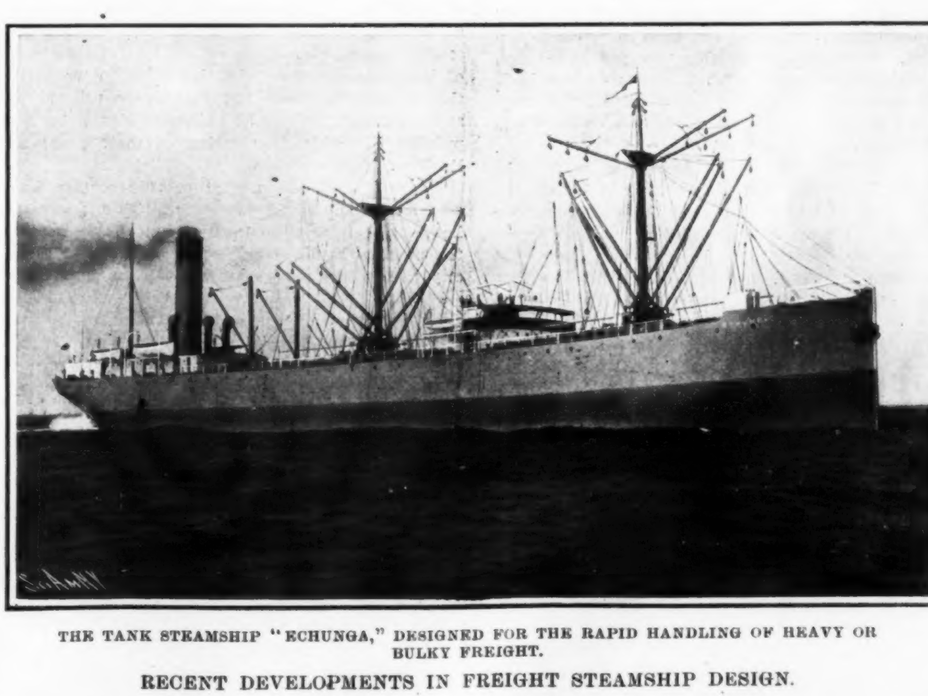
The U. S. Department of Agriculture has issued a Forest Service Bulletin in which H. B. Holroyd and H. S. Betts give a detailed account of an investigation of vehicle and implement woods. The conclusions reached are as follows. The samples, representing different grades, or classes, were selected by experts with a large experience in the vehicle industries, and were thoroughly representative.

The spoke tests showed an error of more than 50 per cent in the present grading system, which is largely due to the traditional prejudice and consequent discrimination against red hickory. No red spokes are now allowed in the A and B grades, yet these tests show that a large proportion of the red spokes now included in the lower grades should, because of their strength and toughness, be included in the highest grades.

The superiority of hickory in toughness and shock-resisting ability, as compared with maple, was brought out in the axle tests. It is probable that no native species has the mechanical properties possessed by the higher grades of hickory, which should on this account be saved for such parts as are subjected to the greatest stress. The shaft tests indicate that red oak may be substituted for hickory of the lower grades in shaft manufacture.

The difference in toughness between oak and such woods as southern pine and Douglas fir is shown in the results of the pole tests. Both of these latter species, however, when carefully selected, appear as promising substitutes for second-grade oak in pole manufacture.

The terms "second growth" and "forest growth" are so loosely applied in the designation of grades that they are confusing and might well be discontinued. These terms, as used by the trade, distinguish between good and poor wood and disregard the true meaning of the words. In order to use the terms in their



THE TANK STEAMSHIP "ECHUNGA," DESIGNED FOR THE RAPID HANDLING OF HEAVY OR BULKY FREIGHT.

RECENT DEVELOPMENTS IN FREIGHT STEAMSHIP DESIGN.

correct sense the particular species and conditions of growth would have to be known for each piece of material. Commercially this is impossible. In reality a large per cent of the stock which is classed as "second growth" is "forest grown" stock of good quality. As changes in the forest take place, due to lumbering and new growth, it may be asked at what point does the wood cease to be "forest grown" and become "second growth." The manufacturer can not definitely answer this question and can not tell but that it is possible to secure both kinds of stock from the same tree. The term "black hickory" is also confusing when used to designate a grade, because it is the accepted common name for certain species.

There is much discrimination in the trade against defects, such as knots and checks, but little is said about crossgrain. The tests have continually shown that in such material as spokes, axles, and poles crossgrain is one of the most serious defects. Defects that will be removed in finishing should not be considered defects by the inspector. Clauses in grading rules such as "Clear of any defects impairing the strength" are too indefinite.

The most useful result of the vehicle-wood investigation is the placing of red hickory in its proper class. The real worth of red hickory, as shown by test and not by color, is a point that should not be lost sight of.

THE BASIS FOR A NEW GEOLOGY.—II.*

RAISED BEACHES AND THEIR CAUSE.

BY H. W. PEARSON.

Continued from Supplement No. 1681, page 188.

XIII.

It has been the custom of many observers to stand upon some beach, say at Lake Nipissing, and *guess* as to where that particular beach, if prolonged, would intersect the shore line at some distant point, as for instance, Duluth or Mackinaw. Or they may stand at Imlay, Mich., and assume that the 849-foot Imlay terrace is identical with the second beach of Gilbert in Ohio. Or, taking still longer flight, M. de Lamothe made such correlation across the entire width of the Mediterranean, and assumed the beach of fifty-five meters in Algiers to be identical with the beach of sixty meters in Southern France. (Bulletin de la Société Geologique de France, May, 1904, page 38.)

All such guesses may, of course, be right, but they are much more likely to be wrong. In any case they are absolutely inconclusive and should never be attempted. A better plan, over *narrow waters*, is to bring to the borders of these waters an established gradient from direct observation of distant beaches, and project this gradient directly over the waters to the opposite coast line. This method, so useful over small distances, will fail in *wide waters* for the reason that the inclination of these terraces in a north and south direction is always changing, and is *invariably in excess in southern regions.*

This method, however, is now not necessary, as the law of sines, when proper corrections have been made for variation in elevation of beaches, for change in topographical condition as previously mentioned, will always provide absolute correlation, or at least within limits of error not exceeding two or three feet.

I have now enumerated, in so far as recollection serves, the more important difficulties encountered in my study of the raised beaches. Other points of less interest might be advanced, but this paper has already overshot my aim.

On reflection, it would seem that from the many protests herein contained, it might be inferred that objection is made to the advancement of new ideas, theories, or speculations as to the causes of glacial or other phenomena. This has not been my wish in the slightest. Speculation invariably precedes knowledge, and should be welcomed. What I have desired is to protest emphatically against the adoption, the mapping, the publication, of bare conjecture or ingenious speculation as ascertained and accepted fact.

For instance, if the map of Agassiz in its finished elegance (see Monograph XXV) be laid before the unsuspecting, of whom there are millions, such persons would at once exclaim "Finis." All is apparently complete. Exact knowledge in this region has nothing further to bestow upon us. The area, the form, the position, the limits of that lake seem to be as permanently, as immutably fixed as those of Superior itself. But if this map be exhibited to the few who have studied this matter, of whom there are units only instead of millions, all is different. These men will regard the pictured result as a mere product of the imagination. They know that we have acquired information as to a few hundred miles of the coast line; but as to the actual area, the actual form, the limits to the north, its extension to the east, *we as yet know absolutely nothing.* Lake Agassiz (so called) may be ten times, or one hundred times, as large as

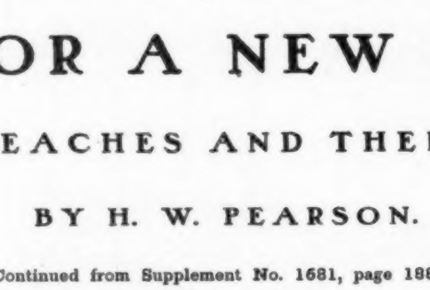


Fig. 4.—The Raised Beaches of the North in Profile.

therein indicated, and no one can yet say intelligently to the contrary. It is to such manner of publication and dissemination that objection is, and ought earlier to have been made.

In our previous paper we mapped the approximate limits, in so far as they have become known to us, of those low-lying regions in eastern North America, which contain surface evidences of having been recently submerged beneath the waters of some overlying lake or sea. If one should now enter upon the serious study of these ancient water bodies by making examination of those evidences which are most decisive as to their former existence, namely, the Great Raised Beaches, he would soon encounter most unexpected difficulties. He would learn, for instance, that to-day we have little knowledge as to these terraces; that our ignorance in fact is so all-pervading as to be oppressive. He would discover that to these strand lines certain methods of study have been applied which must hereafter be abandoned, as they have led to results that either conflict among themselves or are inapplicable to facts of later accumulation. Furthermore, he would learn that as yet we have not sufficiently utilized these ancient water surfaces as *reference planes*, for which purpose the wide distribution of their fossil shore lines especially fits them.

The utility of the present oceanic surface, considered as a plane of reference for all things terrestrial, has long been recognized. By its means we determine the amount of distortion, elevation, or depression at any part of the earth's surface. If we now conceive the present oceanic surface to be considerably lowered, and to different amounts in different latitudes, it is plain that the amount of this movement at any point which was on the old coast line can be accurately determined by comparison of the old with the newer sea level. In such manner the raised beaches, as points in proof planes, might have been used, by which means all suspected tilting, warping, or differential motion in the earth's crust, since the epoch of these terraces, might have been measured with great accuracy.

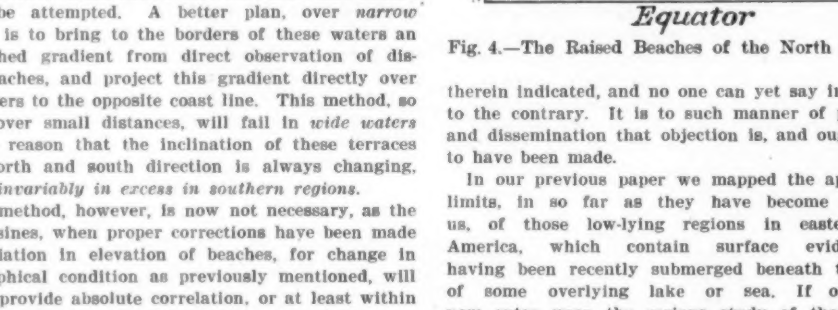


Fig. 5.—Diagram of the Earth's Orbit.

Ten thousand years ago the earth's axis had the direction D-C. Winter then occurred in the north when the earth was farthest from the sun, and according to the Adhemar-Croll hypothesis this was the cause of the Glacial Epoch.

We will now set forth, with such brevity as may be compatible with clearness, some of the results which have been obtained by the present writer in a prolonged examination of these abandoned shore lines during which study the methods and processes advocated in our previous paper were put into practice, with especial emphasis upon the use of these terraces as ordinates, fixing the position of certain proof or reference planes.

To the performance of the above-named labors some twenty-five years have been devoted, and travel to the amount of nearly 300,000 miles has been accomplished, of which many thousand miles were made on foot. It cannot be held, therefore, in those cases wherein conclusions or findings different from those of preceding students have been arrived at, that hasty or inconsiderate action may have been taken in obtaining our results. It would seem more probable, to one well informed in these matters, that the discordant values attained may have been due rather to the great difference in the amount of data placed under examination.

It has been too often the practice, heretofore, to adopt hypotheses or explanations when but a small fraction of the accessible facts have been acquired, and these facts gathered perhaps in such mere fragment of a single basin as is contained in a particular state or country. In our case, however, we have attempted to accumulate all accessible data for all basins, with special regard for the relation which may be found to exist between the levels of the separate basin areas, before undertaking deductions or explanations of any kind. The one system, it will be seen, is distinctly *local*, the other is *general*, and to this difference in method may we attribute much of our difference in result.

Our investigation of these terraces began about the year 1883, along the abrupt and often precipitous shore lines at the head of Lake Superior. Here can sometimes be found within two to five miles of the coast from ten to twenty of these ancient beaches, ranging in altitude through a vertical distance of 500 to 600 feet.

The so-called Boulevard Beach, in this vicinity, has an elevation of from 1,073 to 1,077 feet above the sea, or about 475 feet above Lake Superior. It is the most deeply impressed of all the ancient terraces of the Superior basin. It is supposed to have been carved at the highest level of the waters of Lake Warren (Spencer) and has received its present name owing to the fact that its wide and extended terrace has been absorbed into the park system of the city of Duluth.

In manner accidental our research originated through the curiosity inspired by the observation that at the level of the Boulevard Beach a great change in appearance of these shore lines took place. The Boulevard, and all fellow beaches below its level, seemed sharp and angular in their limiting outlines, presenting every evidence of youth; while all beaches above this level gave proof of much erosion and degradation and appeared, in fact, in comparison with the first named of an immense antiquity.

These observations as to the apparent greater age in the higher terraces, and the abrupt transition, without gradation, with which the change in appearance took place, were so perplexing and so impossible of explanation at that time that interest was aroused sufficient to induce the beginning of a systematic search for all that others had said, done, or thought in the matter of these terraces.

In a short time, as information was accumulated, it became evident that the Boulevard Beach was not horizontal, as one would expect under the hypothesis then entertained, that these shore lines had resulted

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

from the ponding of the waters by an ice dam at the eastern end of Superior, but had considerable rising inclination to the northeast. It was furthermore noted that one or two of the lower terraces seemed to have a flatter inclination than that of the Boulevard Beach. In other words, the first indication of a *fanlike structure* in these terraces had been encountered, but the enormous importance of this discovery was not then appreciated.

During the two or three years following many ordinates from many sources, but largely personally gathered, had been tabulated and plotted, and this work led to the conclusion that the beaches of the south shore of Lake Superior, between Duluth and the base of Keweenaw Point, were practically horizontal.

About this time, by reason of the greater convenience in plotting ordinates from certain writers who had used a great variety of scales in their mapping, the happy expedient was adopted of recording and plotting all ordinates in their proper latitudes and longitudes, instead of by distance in miles as formerly.

The accessible data as to Lake Superior having now been exhausted, the plotting of the beaches of the southern extremity of Lake Agassiz, as given by Warren Upham in the Eleventh Annual Report of the Geological Survey of Minnesota (Monograph XXV. not being then in existence) was entered upon, although a systematic reduction of the elevations of the summits of the *beach ridges* to the elevations of the *beach angles* was first necessary, as has already been shown. This correction required many personal visits to the region. Owing to the fortunate circumstance that Southern Agassiz and Lake Superior are in similar latitudes, the Lake Agassiz elevations were plotted upon the same diagram which already contained the Superior terraces, each ordinate in its proper latitude as before. The immediate result of this action was most startling. It was at once seen, as has already been stated, that in equal latitudes Lakes Warren and Agassiz had held precisely the same elevation above the sea, and that their beaches had precisely the same rising inclination to the north.

It was now realized that this identity in elevation and gradient in two water bodies so widely separated was a perplexing circumstance additional to the many which had preceded. The most obvious explanation of similarity in elevation would seem to be found in the assumption that Agassiz and Warren had in their time been confluent and contemporaneous seas, but this surmise seemed to offer no explanation of the equality in northward inclination, and moreover seemed to offer violence to the belief then entertained of a great glacier in the bed of Superior slowly retiring to the eastward. Then again certain preliminary observations of beaches in the Driftless area of Wisconsin (the glacial Lake Hennepin of later writers) far to the south of Superior, in a region which by no possibility could have been ponded by the Superior or Agassiz glaciers, led to the strong suspicion that in this distant territory a third body of water had existed whose upper surface had been merely a continuation of the already established gradient in the two water bodies at the north.

Entirely unable to explain these uniformities in elevation and gradient, it was now resolved to undertake the accumulation of all known beach data in the United States and Canada, with the object of learning as to how far the horizontal east and west beaches could be followed and as to the limits at the north and the south of the inclined water surface we have been discussing.

It was soon learned that the upper surface of the so-called glacial Lake Ohio, the beaches of which have been studied by Stevenson, Jillson, White, Wright, Claypole, Hice, and others, also formed a continuation of that same line of inclination already found for Agassiz and Superior; it being understood that careful discrimination had first to be made as to the altitude of the dividing line between the recent and older terraces. These terraces were then prolonged to the south, as has been shown in the previous paper, well into the area of the Lafayette submergence, establishing thus the unity and confluence of the Ohio and Lafayette water bodies.

In a similar manner the line of inclination was then slowly extended to the south, many years being devoted to this task, through Kentucky, Missouri, Arkansas, Texas, Cuba, and the Antilles, to the northern coast of South America, and in the opposite direction through New York, Canada, Nova Scotia, Newfoundland, and Labrador to the most northerly islands of the Arctic regions. In this extension there seemed no possibility of error in the proper correlation of terraces between the limits of Texas and Nova Scotia, owing to the great mass of evidence examined, and but little probability in the more distant extremities of our curve.

By identical processes the horizontal lines in the east and west terraces were then carried along the north shores of Lakes Erie and Ontario, through New York to Maine and Nova Scotia, where they were found to harmonize with and become absorbed into the Champlain terraces, which fringe the Atlantic border from Alabama northward to Greenland.

With vastly less labor, owing to our long experience in America, the beaches of England, Scotland, Ireland, Norway, France, Spain, Malta, Sicily, and the Mediterranean coasts generally were then brought into order; the ordinates extending from Spitzbergen at the north to Tunis, Asia Minor, and the Red Sea at the south, and the result of all these labors, prosecuted with great diligence from 1883 to 1896, was the production of the curves as exhibited in the accompanying diagram. (Fig. 4.)

If we now examine and analyze this diagram, it will seem necessary, if these curves represent the actual facts, that certain conclusions be adopted, not in conformity with present beliefs; for example, the extraordinary symmetry and continuity in our lines of inclination demonstrate that the terraces of all countries and of all latitudes *belong to one and the same system*, and therefore the one explanation must satisfy all beach phenomena. If, for example, ice dams will not explain the terraces of the Red Sea, Cuba, or Malta, they must be forbidden in the case of Agassiz or Iroquois. Again, the concentric nature of these curves, and the regularity with which the several inclined members pursue their course for thousands of miles, most positively eliminate the idea of utilizing the chance upheaval of the earth's crust in explanation of their elevated position. The observed perfection of figure in the profile of these shore lines must rather be the *expression of some general law* hitherto unrecognized. Chance evidently has no place in this diagram. Furthermore, this same perfection of figure assures us, contrary to modern doctrine, that since the epoch of these terraces, no local warping, tilting, or deformation of the earth's crust can have occurred, or such motion would have been both traceable and measurable in these curves.

Now then, if glacial dams and chance upheaval of the crust are both to fail us when we seek for explanation of these strange facts in the raised beaches, it is our duty to look elsewhere, and in such a search it is soon discovered that there is but one physical cause that can be considered adequate to our needs, and this may be stated as *the displacement of the earth's center of gravity by the accumulated ice of the last glacial epoch and the consequent submergence of all northern shore lines.*

In Dr. Croll's "Climate and Time" (page 387) consideration is given to this question. The computations of several mathematicians are exhibited, and the competence of the northern glaciers to produce a submergence to the amount of 2,000 feet at the pole is affirmed. (Rev. O. Fisher.) The calculations above mentioned, which have been confirmed by later writers, it is seen will readily explain our most recent terraces, which if extended to the pole would have at that point an elevation of about 1,467 feet; but these younger shore lines are not the only ones requiring solution. As we have previously shown, many older systems of these terraces are in existence which also need explanation.

In hopes of finding some possible origin for these older systems, therefore, let us now examine the Adhemar-Croll hypothesis as to a cause for glacial epochs, as it is plain that if logical and plausible reasons can be given for a recurrence in glacial conditions, we should expect the number of terrace systems to correspond with the number of ice invasions.

In "Climate and Time" Dr. Croll expands and illustrates this theory, which had been previously advanced by M. Adhemar. He shows that winter in the northern hemisphere now occurs when the earth is 3,000,000 miles *nearer* the sun than at the time of the Antarctic winter. He shows also that owing to the slow swaying of the earth's axis through the precessional period of 21,000 years (the actual period of 25,800 years being reduced to 21,000 by motion in the major axis of the earth's orbit) these conditions will be reversed in 10,500 years, and will continue to so oscillate forever. He then advances a strong argument, and one that has been accepted by many scientists, that such hemisphere as, for the moment, has its winter when farthest from the sun (in aphelion) must necessarily have a lower mean temperature than its opposite, and he holds that these lower temperatures, alternating at either pole in regular succession at intervals of 10,500 years, may have been the occasion of glacial epochs, and if so these perplexing ice caps and their resulting inundations must repeat themselves in regular cycles.

Sir Archibald Geikie has pronounced this idea of a cause for glacial epochs "the first fruitful suggestion in this matter." Dr. Ball, Alexander Winchell, Wallace, and others have also supported the hypothesis. Moreover, after a very slight examination it was seen that all important conditions of our problem would, through its means, be accurately satisfied. For example, the theory would seem to completely explain the form and geographical position of our curves with apex at the poles; it would explain the many repetitions of glacial conditions and the several systems of elevated shore lines; it would tell us why the southern hemisphere is to-day the colder, and why the northern glaciers, which all admit have recently covered the north, should have disappeared so recently as within 5,000 to 10,000 years of the present; and finally the idea explains why there should be to-day, in the south, an ice cap with cubic contents at least forty-fold in excess of that in the north.

Fig. 6.—Map of the Eastern United States, Showing the Last (Boulevard Beach) Submergence.

It was now recognized that a possible solution to all the problems which for years had engaged the writer's attention was in sight, provided the assumption could be made that a succession of glacial epochs in the north had occurred at intervals of 21,000 years.

Up to this point in our research the main impelling motive in our labor had been the curiosity inspired by the certainty with which the upper levels of the so-called glacial lakes had fallen into one continuous spherical surface rising invariably with inclination fixed by law, always to the true north. This result, so unexpected, so unaccountable, kept alive our interest.

Now, however, a much stronger motive appeared. We had established, as has been seen, a recent submergence of the entire North, and had but now encountered a cosmic law which apparently was capable not only of explaining the submergence, but seemed also able to fix its epoch as within a very few thousand years of the present.

Consideration of these facts led at once to the strong suspicion, we might almost say conviction, that during

the many long years in which we had been engaged in this investigation, we had apparently been following, in blindest ignorance, the traces and records of the Biblical Flood. Our interest in the many problems which had arisen was therefore much increased, especially after learning that Prof. Prestwich had reached a conclusion very similar, in his study of the Asiatic, African, and European beaches. ("Tradition of the Flood," Macmillan & Co., 1895.)

One of our earliest labors, after the additional impetus above mentioned had been given, was to map out, in all parts of the world where the necessary data could be obtained, the extent, form, and position of all those areas which had been submerged by the last northern inundation. In Fig. 6 such areas are shown for that portion of the United States south of the continental glacier, this latter having been delineated from limits fixed by the American geologists. (Seventh Annual Report U. S. Geolog. Survey.) When comparison is now made of the above-described map and a similar one which was constructed for Europe, with the colored geological maps for America and Europe, a most surprising correspondence is disclosed between the bounding limits of the recently submerged areas and the bounding limits of the most recent rock formations. For instance, in mapping out by aid of the beaches the recent flooding of Europe, *we reproduce almost precisely*, in a great many regions, Sir Charles Lyell's map of the Tertiary submergence of that continent. In England for long distances the Pliocene seems limited by one of our deeply impressed lower beaches, and the same condition is repeated in the more elevated deposits of the Lower Tertiary and Cretaceous. In the United States the "Columbia" formation in the south coincides largely with lower beach limits, and the more extended deposits of the Lafayette have already been shown nearly identical with the most recently submerged area in the Southern States.

MALE BLUEBIRD.

HOUSE-CLEANING.

This correspondence between those submergences which were now apparently amenable to law and chronology and those geologic formations for which neither law nor chronology had ever been suggested, was astounding. It seemed certain that in the one we could find cause, and in the other effect. The formations evidently were related to and dependent upon the submergences; and if this deduction should be confirmed by more extended examination, the logical conclusion would be that eventually, when more perfect correlation between particular submergences and particular formations has been accomplished, we may be enabled to introduce a *time scale* into all geologic history.

The inference above arrived at, so vastly important to the future of geology if well founded, was not hastily reached. For a considerable period it was regarded as absurd to assume such youth as has been mentioned for the Upper Tertiary. It was soon learned, however, that Prof. Marcou, Hugh Miller, James Geikie, Alfred R. Wallace, Dawkins, and others had already made this same assumption; the latter saying "The Tertiary must be extended so as to embrace our own times." ("Early Man in Britain," page 497.) This objection therefore was considered of little weight, and the last and most important stage of our long labors was entered upon, viz., the serious study of the existing relations between the older geologic formations and the older glacial submergences as indicated by the raised beaches.

(To be continued.)

HOME LIFE OF THE BLUEBIRD.

THE STORY OF A HARBINGER OF SPRING.

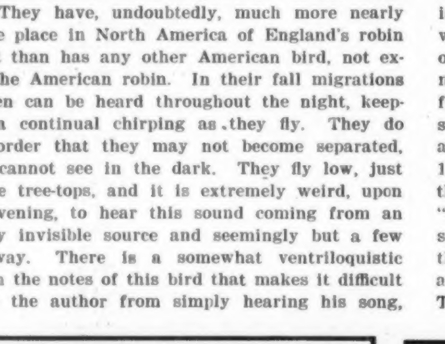
BY L. W. BROWNELL.

IN northeastern North America the days of the latter part of February and early March are still cold and cheerless, with the snow lying deep upon the ground, and the ponds and streams still ice-bound. There spring is but a far-away thought, and the average man would much rather be sitting in front of a good fire, or near a steam radiator, than tramping abroad through the fields, unless, as sometimes does happen, he proves to be a sincere lover of nature. If he is such a *rara avis*, and if he really cares to risk a pair of frosted hands, feet, or ears, by taking a tramp into the fields and byways upon such a day, he will not have to go far, if he is lucky, before he will be rewarded by hearing a faint, rather plaintive "chee-eep," "chee-eep," "chee-eep," dropped from out the sky above his head, and, at first glance, apparently emanating from nothing at all. A little closer observation, however, will show him a bright bit of color fluttering down against the pure white background of snow, to settle upon the limb of a tree or the convenient wire of the telegraph, and, sitting there, give utterance again to those two or three plaintive little notes that first arrested the attention of the observer.

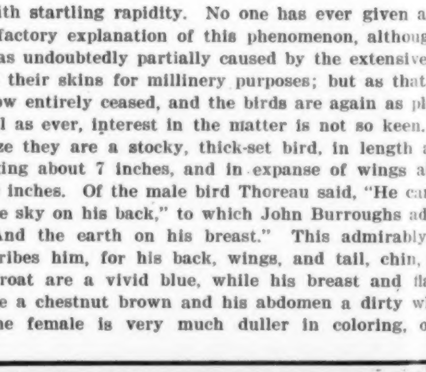
This is the bluebird, commonly called the "harbinger of spring." To my mind, however, he is not so true a heralder of the coming balmy days as is the song-sparrow, for the latter is wont to attempt his cheery little song even earlier in the year than this. But the bluebird is a good second, and when we hear his unmistakable song, if song it can be called, we may be certain that winter's days are numbered, and that very soon the snow and ice will begin to disappear and give place to the green of the early springtime. In point of fact, many bluebirds remain with us all through the winter months, and they may be found at any time in small flocks feeding upon the many varieties of frozen berries that still adhere to the trees and bushes, and which, at this season, form their chief and often only food. It is then that their plumage is at its best, and shows to greatest advantage. Those of them that have not the hardihood to spend the entire winter North, seldom leave until after the rest of the migrants have departed, sometimes staying until well into December. Even then they are content with but a couple of months in the South, returning again about the middle of February, or at the latest the first of March. They cannot come too early or stay too late, however, for with their shy, retiring, and inoffensive habits, and their beautiful plumage and plaintive voice, there is no man or woman who knows them to whom they do not endear themselves. They have, undoubtedly, much more nearly taken the place in North America of England's robin redbreast than has any other American bird, not excepting the American robin. In their fall migrations they often can be heard throughout the night, keeping up a continual chirping as they fly. They do this in order that they may not become separated, as they cannot see in the dark. They fly low, just above the tree-tops, and it is extremely weird, upon a still evening, to hear this sound coming from an absolutely invisible source and seemingly but a few yards away. There is a somewhat ventriloquistic quality in the notes of this bird that makes it difficult to locate the author from simply hearing his song, and I have often looked in vain for several minutes when I knew that the singer was within a few feet of me, only to give up in disgust, and then see him sitting in exactly the opposite direction to that in which I had been looking. There is no other American bird that I know of to whom will better apply Wordsworth's questioning characterization of the English cuckoo:

> "Shall I call thee bird,
> Or but a wandering voice?"

Several years ago it was feared by many that these birds were becoming extinct. In many localities where they had before been plentiful their numbers decreased with startling rapidity. No one has ever given a satisfactory explanation of this phenomenon, although it was undoubtedly partially caused by the extensive use of their skins for millinery purposes; but as that has now entirely ceased, and the birds are again as plentiful as ever, interest in the matter is not so keen. In size they are a stocky, thick-set bird, in length averaging about 7 inches, and in expanse of wings about 10 inches. Of the male bird Thoreau said, "He carries the sky on his back," to which John Burroughs added, "And the earth on his breast." This admirably describes him, for his back, wings, and tail, chin, and throat are a vivid blue, while his breast and flanks are a chestnut brown and his abdomen a dirty white. The female is very much duller in coloring, often having a reddish tone that extends from the middle of the back over the shoulders. The Seminole Indians will tell one that the male bluebird once flew so high that his back rubbed against the sky, which imparted to him its own azure tint. Returning to earth, his wife so admired his new coat that she determined to have a like one for herself, and the next morning flew away to get it; but the day proving somewhat cloudy, the color given to her dress was not so brilliant as was that received by her mate.



AT THE ENTRANCE TO THE NEST.



YOUNG BLUEBIRDS.

Their range extends over nearly all of the eastern portion of the United States, west as far as the slope of the Rocky Mountains, and north to Manitoba, On-

tario, and Nova Scotia. They breed nearly throughout their entire range. In winter they pass south to the Gulf States and Cuba, and, occasionally, are found as far north as southern New England. They are resident in Bermuda. In southern Arizona and eastern Mexico there is a sub-species of this bird—the azure bluebird. The Mexican bluebird is not found in the United States, but is represented in the West by three sub-species, to wit: the western bluebird on the Pacific coast, the chestnut-backed bluebird in the Rocky Mountain district, and the San Pedro bluebird of Lower California. In the interior of the western portion of the United States is the only other species native to North America—the mountain bluebird. Thus it will be seen that virtually every part of the country has its bluebird.

As a building site they prefer—if it can be found—a deserted woodpecker's hole. When they cannot find this they content themselves with any cavity of sufficient size in a tree or stump; but they never excavate one for themselves. I have found them nesting in the top of a post, the heart of which had rotted to a depth of 4 inches or 5 inches, thus forming a cup-shaped hollow, open to every shower. A bird-house is readily accepted by them; but they are easily driven therefrom by either the house-wren or the English sparrow, as they are too gentle in disposition to fight very hard for their rights. They are very partial to an old orchard in which there are many dead trees or branches, or to a burnt-over swamp in which many rotting tree stubs are left standing. A pair of birds will return to the same nesting site year after year, as long as it remains at all suitable for their purposes, and when they fail to return in the spring it is safe to conclude that some serious misfortune has befallen one, or both. They never build high, rarely more than from 15 feet to 20 feet above, and more often within 7 feet or 8 feet of, the earth. The nest itself is built almost entirely of dried grasses, with occasionally a few feathers or other soft material, and sometimes one or two horse-hairs. In reality, it is little more than a rather scanty lining to the cavity. It is impossible to give any accurate dimensions of a typical nest, as these are entirely governed by the size of the hole in which it is placed.

They are the first of the smaller birds to begin their housekeeping arrangements, and the site for a nest is selected and the nest built usually before the middle of April. It is no unusual occurrence to find eggs in the nests even as early as the first of the month, and with the majority they are laid by April 25. These eggs, of which from four to eight, most often either five or six, are laid in one litter, are of a light turquoise blue, slightly glossy, and immaculate. In intensity of color they vary but little in a long series, but occasionally an almost pure white one will be laid. In size they average 87-100 inch in length by 65-100 inch in breadth. While in the act of incubating her eggs the female is a most devoted little mother, as it is sometimes difficult even to drive her from them. I have one case in particular in mind, a nest found by myself containing eggs, which I wished to photograph. The female was sitting upon them, and remained there with the most indomitable courage even after I actually put my hand on her, and it was necessary for me to forcibly remove her from the nest before I could take the photograph showing the eggs. Whether this is an evidence of extreme courage or timidity it is hard to determine. On the face of it, it would seem to be the former, but it may well be that the bird is actually too frightened to leave of her own accord. This conjecture is somewhat borne out by the fact of her abject timidity at other times, for neither she nor the male bird will fight in defense of their home and young, as will nearly every other bird, but content themselves with sitting upon the branches of adjacent trees and giving repeated utterance to their plaint. They are not easily driven to desert their nest, however, but will, in most instances, return to it after the visit of an intruder, unless it has been badly demolished. I have known them continue to use a nest soon after their eggs have been removed from it, and in any case they will not go to a great distance from their former site in searching for a new one. In this respect they exhibit an amount of confidence in human nature that is often misplaced, but which nothing seems to shake. Their nature is a most peculiar mixture of shyness and boldness, confidence and timidity.

They usually raise two, occasionally three, broods in a season. I have often found nests containing eggs as late as the middle of June. As soon as the first brood leaves the nest the father bird takes almost exclusive care of them, while the female searches out a new nesting site, and starts the making of a new home for the second brood of youngsters. The second litter is rarely as large as the first, generally consisting of but four or, at the most, five eggs. When the second nest is complete and the eggs laid, the father leaves his first family to shift for themselves, for then all his time will be occupied in attending to the wants of his mate. They rarely use the same nest for both broods, probably because of the fact that by the time the first have left it is so infested with lice as to be hardly a comfortable home for the second brood, though the fumigating effect of a winter's storms so purifies it that, with the little repairing necessary, it is fit for occupancy again the following spring. The young for the first three or four months of their lives resemble their parents but little. Their backs and wings are a slaty blue, and their breasts look more like the breast of a young robin, being of a ruddy brownish hue and thickly spotted and splashed with white. It is not until well into the fall that the white spots disappear and the back and wings begin to acquire the vivid coloring of the old birds. During the middle summer and the fall months the bluebirds are very little in evidence, and even their plaintive warble is hushed, so that often we may look for one in vain. They have retired from active life for a season, to reappear again in smaller numbers when the snow is once more upon the ground.—Country Life (London).

SUNS AND NEBULÆ.—II.*

AN ALTERNATION OF GENERATIONS.

BY SVANTE ARRHENIUS.

Concluded from Supplement No. 1681, page 190.

THE new stars form a sub-division of the variable stars. An example of the latter is Eta in Argus, which was classed in the 4th magnitude in 1677, in the 2d in 1687 and 1751, and in the 1st in 1827. Then Herschel found that it fluctuated between the 1st and 2d magnitudes, but in 1837 it increased rapidly in brilliancy and in 1838 so far outshone the typical 1st magnitude stars that its magnitude was denoted by 0.2. But in the following year it declined to the 1st magnitude and there remained until 1843, when it rapidly brightened until it outshone every star except Sirius (magnitude —1.7). Thereafter it slowly declined to the 6th magnitude, and since 1869 has fluctuated between the 6th and 7th. These observed changes point to a great collision in 1843 and a smaller one in 1838. The smaller collision may be compared to the fall of the earth into the sun, which would develop heat sufficient to supply the solar radiation during 100 years. From the older observations it appears probable that the star suffered at least one earlier collision.

New stars are discovered almost yearly. Most of them appear in or near the Milky Way, where the visible stars are most densely aggregated and a collision visible to us is most likely to occur. Here, for the same reason, are most of the star clusters and gaseous nebulæ. Far from the Milky Way, where stars are sparsely scattered, are found most of the nebulæ with stellar spectra. These are simply star clusters so remote that the individual stars cannot be distinguished.

Many variable stars exhibit irregularities in periodicity and brightness that resemble those of the new stars. One, Eta in Argus, has been described. Another is Mira Ceti, the first star recognized as variable (1596). Its average period is 11 months, but the period varies irregularly. The maximum brightness varies from the 1st to the 5th magnitude. At the minimum the star falls below the 6th magnitude (becoming invisible to the naked eye) and occasionally below the 9th. In other words, the maximum is 1,000 times the minimum luminosity. The shifting of the spectral hydrogen lines indicates that the star is surrounded by three nebulous envelopes, the innermost uniformly distributed and the others forming a ring with two points of maximum density corresponding to the traces of two eruptive streams. This ring revolves in 22 months and has a linear velocity or rotational velocity of 14.6 miles per second. Hence it follows that the diameter of the ring is 1.45 times that of the earth's orbit and that the mass of the central star is slightly less than that of the sun.

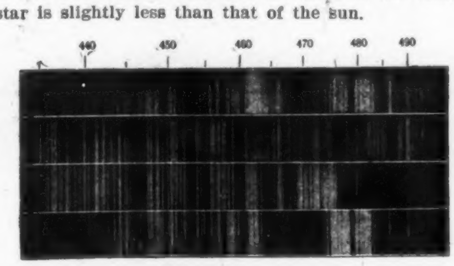


FIG. 10.—BLUE PART OF SPECTRA OF STARS OF VARIOUS CLASSES.

Beginning at the top the order is class 4, class 2, class 3, class 4.

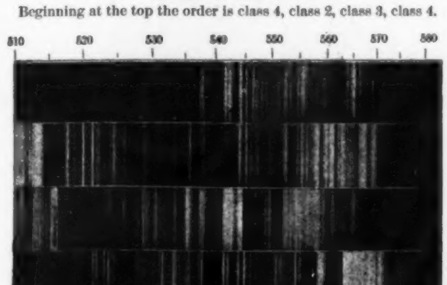


FIG. 11.—GREEN AND YELLOW PART OF SPECTRA OF STARS OF VARIOUS CLASSES.

Beginning at the top the order is class 4, class 2, class 3, class 4.

SUNS AND NEBULÆ.

Most of the variable stars belong to the type of Mira Ceti. That is, they are red and give continuous spectra crossed by dark bands and bright hydrogen lines. Chandler has discovered that the variable stars of longest period are the reddest. This is easy to understand, for the volume, period of rotation, and absorptive effect of the dust-laden gaseous envelopes must increase together. The spectral bands of these red stars indicate the presence of chemical compounds, but this does not imply low temperature, for sunspots give very similar spectra. It does imply high pressure.

The variability of stars of another class—the Lyra type—is usually attributed to eclipses by dark companions, but the presence of dust rings also is required to account for all the phenomena, though the white or yellow color of these stars indicates that dust plays a less important part with them than with the red Mira stars. Their periods, too, are measured by hours and days, while those of the Mira stars extend to months and years.

For the white variable stars of the Algol type the theory of a dark or luminous companion suffices and the spectroscope indicates the absence of dust.

Evidently the earth lies near the planes of the companions and dust rings of all variable stars. Otherwise there would be no variation, but the Algol stars would appear as spectroscopic doubles and the others as nebulæ with dense centers.

According to Prof. Campbell, of the Lick Observatory, the condition of many stars differs little from that of nebulæ, their spectra showing bright lines of hydrogen and helium. Other stars, a little farther removed from the nebulous state, give both bright and dark hydrogen lines. Nearly related to these are the helium stars, which show dark lines of helium and hydrogen and a few weak lines of metals. In this class are the white stars in Orion and the Pleiades. The youthfulness of the stars of all these classes, which was first inferred from their spectra, has been demonstrated by the photographic discovery of their nebulous envelopes. As the star loses heat the helium lines becomes indistinct and dark calcium and iron lines appear. Vega and Sirius are in this stage. Next the hydrogen lines weaken, the metal lines grow stronger, the color changes from blue-white to yellow and the star gradually acquires the present condition of the sun. At this stage the helium lines are gone, only four or five hydrogen lines are left and some 20,000 lines of metals appear, those of calcium being especially prominent. Stars of the sun type appear to be near the maximum development and temperature, for their low specific gravity indicates that they are entirely gaseous. With the continued loss of heat

* Illustrated with photographs taken at Yerkes Observatory.

the yellow star turns red, the hydrogen lines become weaker and the metal lines stronger, and broad absorption bands appear. In one group, Secchi's type III, these bands are of unknown origin; in another group of stars, which are evidently near the last stage of their evolution and constitute Secchi's type IV, the bands are known to be due to carbon compounds. Secchi's type III includes Mira Ceti and hundreds of other variable stars of long period. At their maximum brilliancy these stars show bright lines of hydrogen and other elements.

The above is a summary of Prof. Campbell's statement. It has already been pointed out, however, that the red color of the Mira stars is due to dust and not to low temperature. The extreme brilliancy of Arcturus and Betelgeuse, which are redder than the sun, indicates that they are intensely hot.

The stages that follow Secchi's type IV are illustrated by Jupiter, which is probably still gaseous, and the earth, which has acquired a solid crust.

The metallic vapors expelled by the collision of two stars are soon condensed, but helium and hydrogen continue to form a nebulous envelope about the central mass and give bright line spectra, owing to the discharge of the negative electricity of dust driven through the gases by the pressure exerted by the radiation of the glowing nucleus. In the new stars that have been observed this pressure rapidly diminished and the nebulous light paled, but in other stars

$$\frac{Q}{600} - \frac{Q}{1000} = \frac{Q}{1500}$$

According to Clausius, all bodies in the universe tend toward equality of temperature. But if this law has no exception this equality would already have been produced if the universe has existed for an infinite time, or if the universe had a beginning energy must then have been created, in contradiction of the first part of Clausius's law. Hence we are led to seek an exception to the law of entropy.

Maxwell has suggested a hypothetical exception—a vessel filled with gas of uniform temperature and divided by a partition in which is a hole guarded by an intelligent demon who allows only the swifter molecules to pass through in one direction and the slower ones in the opposite direction, thus accumulating the swifter molecules in one compartment or, in other words, producing a difference of temperature, as the temperature of a mass of gas is proportional to the mean square of its molecular velocities. Hence there would be a transfer of heat from a colder to a hotter body, and a fall of entropy.

The same thing occurs in gaseous nebulæ. When the molecules of the atmosphere of a heavenly body have sufficient velocity—11 kilometers per second for the earth—they fly off into space. To this cause Stoney ascribes the loss of the moon's atmosphere. At the surface of an extended and tenuous nebula this escape

Below these three gases may lie nitrogen, simple hydrocarbons, cyanogen, oxides of carbon, etc., and near the center of the nebula sodium, magnesium, and even iron vapors. Ritter has investigated the conditions of equilibrium in a gaseous mass obeying the laws of gases and hence having a density less than 1/10 that of water or 1/14 that of the sun. Schuster has applied Ritter's results to the sun, to which they are not strictly applicable. I have therefore adapted Schuster's calculation to a mass equal to the sun's, expanded to 10 times the sun's linear dimensions.

The results are:

Distance from Center (Radius = 1).	Specific Gravity.	Pressure in Thousands of Atmospheres.	Absolute Temperature in Millions of Degrees C.	
			Hydrogen.	Iron Vapor.
0	0.0084	852	2.5	137.5
½	0.0035	200	1.4	77.0
1	0	0	0	0

From the law of gravitation, combined with the law that the product of the pressure and volume of a mass of gas is proportional to its absolute temperature (if heat is neither added nor subtracted) it follows that if the sun were expanded to 1,000 times its present linear dimensions, so that it would nearly fill the orbit of Jupiter and even its central density would be as low as that of the best vacuum tubes, the center would still have a pressure of 6 millimeters of mercury (1/125 atmosphere) and a temperature of about 25,000 deg. C., or 1,375,000 deg. C., according as the

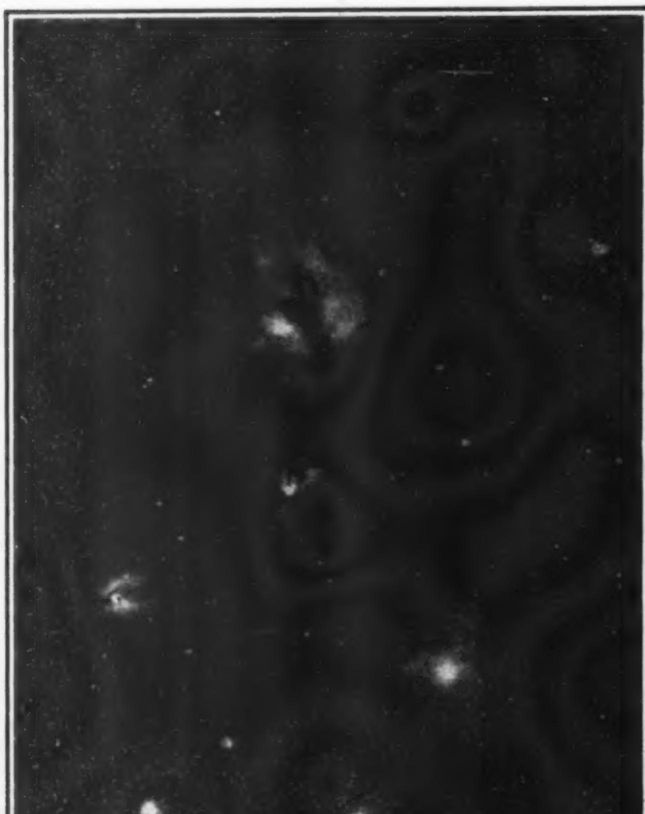


FIG. 12.—GREAT NEBULA OF RHO OPHIUCHI.

FIG. 13.—"NORTH AMERICA" NEBULA.

SUNS AND NEBULÆ

showing bright hydrogen and helium lines the radiation from the nuclei or from neighboring stars appears to continue undiminished for ages.

The helium gradually escapes and forms explosive compounds in other stars, for Ramsay and others appear to have proved that helium forms compounds at high temperatures. The hydrogen then suffers a similar fate and the spectrum of the central mass reveals a preponderance of the vapors of calcium and other metals. At the same time appear chemical compounds, especially compounds of carbon, which abound in the outer parts of sunspots, in stars of Secchi's type IV and in the gaseous envelopes of comets. Their presence does not imply low temperature, for their bands appear in the spectrum of the electric arc and weaken as the current is diminished.

At last a solid crust is formed and the star is extinguished.

The chemical and physical conditions of nebulæ differ radically from those of suns and of ordinary, comparatively dense matter. Nebulæ do not obey the law of Clausius, that energy remains constant and entropy tends toward a maximum.

The entropy of a body is defined as the total quantity of heat which it contains, divided by its absolute temperature. In our experience heat passes only from warmer to cooler bodies and the aggregate entropy is necessarily increased by the transfer. For if Q units of heat pass from a body at 1,000 deg. to one at 600 deg. the aggregate entropy is increased by

of the swifter molecules is facilitated by the feebleness of the central attraction. Now if the universe contained nothing but such nebulæ the molecules escaping from one would be caught by others and the ultimate result would be uniformity of temperature. But many nebulæ contain denser interlopers which have condensed the nebula gas about them and have thereby grown hotter. The wandering molecules may fall into the vast atmospheres of these infant stars and thus accelerate the condensation, the rise of temperature and the fall of entropy. Thus is the clock of the universe wound up as rapidly as it runs down.

Hence the gases which were at the outside of the nebula accumulate about adventitious bodies and the fragments of the "new star," at the rupture of which those gases were generated by the explosive compounds of that star's interior. Chief of these gases, probably, are hydrogen and helium, which can remain uncondensed in appreciable quantities at very low temperatures, at which a single gramme of mercury vapor would fill a cube of which the side would be 450 times the distance from the earth to the nearest fixed star, and a gramme of sodium vapor would be a thousand million times more voluminous. With hydrogen and helium, in the intensely cold outer parts of the nebula, may be associated "nebulium," a hypothetical element to which are assigned two lines characteristic of the spectra of nebulæ, and not produced by any terrestrial element. The boiling point of nebulium, like those of hydrogen and helium, probably lies below —223 deg. C.

mass consisted of hydrogen or of iron vapor. Such a planetary nebula would lose from its surface all molecules having velocities greater than 5 kilometers per second.

Now, Lane has shown that such a nebula must become hotter as it contracts in consequence of loss of heat by radiation, and colder as it expands on receiving heat from outside. Probably the rise of temperature continues until the nebula becomes a white star with an atmosphere of helium and hydrogen which later, at a still higher temperature, diffuse inward and form energetic explosive compounds. As the contraction continues, the temperature attains a maximum and then falls. This occurs (in our example) when the volume is about three times that of the sun. Hence the sun has long been growing colder, but stars like Sirius have probably not yet attained their maximum temperatures or one-hundredth of the sun's mean density.

The planetary nebulæ are vastly larger and more tenuous than Sirius. The largest planetary nebula, in Ursa Major, has an apparent diameter of 2.67 minutes and must be a thousand times larger than Neptune's orbit. Its densest part is probably a trillion times less dense than our atmosphere and its outer portions are kept captive by extremely low temperature or molecular velocity.

Yet its density and temperature must be vastly greater than those of the gaseous portions of the spiral nebulæ. In these spiral streams cosmical dust is

arrested and aggregated into comets and meteorites, which because of their density fall toward the center of the nebula, acquire a motion of revolution from the whirling gases and become the nuclei of planets and satellites. Thus is developed a solar system in which the planets, like the Pleiades, are surrounded by vast gaseous envelopes. Owing to their smaller mass these inchoate planets cool much more rapidly than the central body of the nebula. The resultant contraction shortens their periods of rotation and the tidal action between them and the great central body, supplementing the initial whirl of the nebula, ultimately produces a system in which the planets move in nearly circular orbits nearly in the same plane and in the same angular direction, which is also the direction of rotation of the sun and all the planets, and of the revolution and rotation of the satellites of all except the most distant planets, such as Uranus and Neptune.

To explain these facts Swedenborg, in 1734, imagined a "solar chaos" spinning round the sun with increasing speed until a ring separated and broke up into planets. Buffon, in 1745, conjectured that the planets were formed from a stream of matter carried off from the sun by a comet. Kant assumed a chaos of motionless dust, its conversion by the action of gravitation into a central body with rings of dust circling around it, and the subsequent consolidation of these dust rings into planets. But rotary motion cannot be produced *ab initio* by a central force. Hence Laplace (1776) like Swedenborg, gave his primordial nebula an initial rotary motion and assumed that it threw off rings from which the planets were formed. It is now believed that only small planets and meteors revolving about the sun could have been formed in this way. Saturn still presents an example of rings composed of small satellites which revolve more slowly with increasing distance from the planet.

Laplace would probably not have enunciated his hypothesis in the form which he gave it if he had known, as we do, that the satellites of Neptune and Uranus (and probably the satellites of Saturn which Pickering discovered in 1898) revolve about their primaries in a retrograde direction and in planes which deviate widely from the ecliptic. These exceptions to the general law of motion are easily explained by the supposition that the outer parts of the primordial nebula were so extremely tenuous that the immigrating planet did not develop sufficient volume to be greatly affected by tidal action. It is not inconceivable that the solar system possesses remote and undiscovered members moving in orbits as erratic as those of comets. These planets, as Laplace conjectured, probably joined the system after the condensation of the principal mass had almost freed interplanetary space of nebulous matter.

Chamberlin and Moulton have attempted to show that the difficulties of Laplace's hypothesis can be evaded by the assumption that the solar system was developed from a spiral nebula into which foreign bodies penetrated and condensed the nebulous matter about themselves. The attenuation or disappearance of nebulous matter near stars included in such nebulæ (the nascent planets) can be actually observed in many cases.

In conclusion, we may draw a parallel between the theories which were generally accepted a few years ago and the views which have been opened to us by recent discoveries. The Newtonian law of gravitation, which until 1900 was regarded as the sole governor of the movements and the evolution of the material universe, leads to the continual aggregation of the heavenly bodies into greater masses, so that ultimately all the matter in the universe would be collected into comparatively few large suns, luminous or extinct, on which organic life would be impossible. But we see near our own sun a number of non-luminous bodies, the planets, and we are justified in assuming that other stars are attended by dark companions, by the presence of which alone can the peculiar oscillating movements of those stars be explained. We observe also that myriads of little meteorites or "shooting stars" fall to the earth from space.

The explanation of these discrepancies is given by radiation pressure and collisions between bodies. The collisions give rise to great whirlwinds about nebulous and gaseous nuclei. Cosmical dust, some of which may be aggregated into meteors and comets, is driven by radiation pressure into these whirlwinds where it unites with products of condensation of the surrounding gases to form planets and their satellites.

Thus the distributive action of radiation pressure balances the concentrating action of gravity. The nebulous cyclones merely determine the position of the dust expelled from distant suns by radiation pressure. If, as was once believed, the universe were limited to the great cluster of stars surrounded by infinite empty space, both the matter and the energy carried by radiation from the suns would be lost. On this theory all matter and all energy would have been dissipated and annihilated long ago.

The thin, gaseous, and cold parts of the nebulæ constitute the regenerator of the machinery of the universe, in which the matter and energy wasted by the suns is received and utilized. Here the radiant heat of the suns is caught by immigrant dust particles and communicated to the separate gas molecules with which they collide. In consequence of this gain of heat the entire gaseous mass expands and becomes cooler. The most energetic molecules escape and are replaced by others from the denser interior of the nebula. In this way every ray is absorbed and its energy is carried to new suns in process of formation within or near the nebula while the dust is condensed upon immigrant bodies or fragments of the two suns whose collision gave birth to the nebula. Although, as Poynting has shown, the pressure of radiation is sufficient to keep asunder spherical masses 1.3 inch in diameter, having the density of the earth and a temperature of 15 deg. C. (59 deg. F.) material particles can cohere at the temperature of the nebulæ (about —223 deg. C. or —370 deg. F.) at which the limit of size is reduced to 1/25 inch. Probably the initial aggregation of fine dust is effected less by gravity than by capillary forces due to the gases condensed upon the particles.

And in the nebulæ available energy, also, can be accumulated, in defiance of the law of the continual increase of entropy.

As a result of these regenerative processes the gaseous envelope of the nebula is exhausted and the nebula converted into a star cluster or a group of planets revolving about one or more suns.

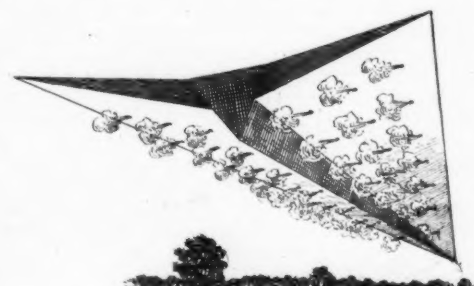
In the transformation of nebulæ into suns and planets and in the production of new nebulæ by collisions of solid bodies, luminous or not, an important part is played by the explosive compounds of hydrogen and helium with carbon and the metals. The laws of thermodynamics lead to the conclusion that these explosive compounds are found in the development of suns and destroyed in their collisions. The prodigious energy latent in these compounds represents the flywheels and governors of the mechanism of the universe and assures the eternal and uniform rhythm of alternation between nebulæ and suns.

This harmonious and compensating co-operation of gravitation and radiation pressure, of equalization of temperature and concentration of heat, makes possible an ever-changing universe without beginning or end, on which life may continue forever.—Condensed from Chapters VI and VII of "Das Werden der Welten."

A NEW AEROPLANE.

By Theodore Gibon.

Since Messrs. Wright brothers and Mr. Henry Farman have made their successful flights, the fact that aeroplane flight is possible cannot be disputed by



A TRIANGULAR MONOPLANE DRIVEN BY REACTIVE FORCE.

anybody any longer. It is time now to point out which improvements are needed to accomplish a more rapid development in the art of flying. Among the difficulties met with are the following:

1. The head resistance of the aeroplanes now experimented with is too large.

2. This already great head resistance is increased every time the equilibrium is lost.

3. In trying to regain the equilibrium by twisting the supporting surfaces and moving vertical and horizontal rudders (as the Wright brothers are said to do), or by moving a horizontal rudder (as Farman does), the head resistance every time becomes entirely too large and results in considerable loss of speed and a consequent loss of carrying capacity. These losses, then, are chiefly due to the constant and wide variation in the angle of attack.

In view of these facts, the question naturally occurs as to what is the proper course to follow to lead to better and perfect success. How can these obstacles be overcome in the best manner?

I believe that this can be, and eventually will be, accomplished as follows:

1. By reducing the head resistance by using an arrow-shaped monoplane with stationary supporting surfaces. This monoplane will be made up of triangles, no matter from what side it is viewed. It will be self-braced in every direction, which also gives the greatest strength to the structure in the simplest manner.

2. By doing away with all movable, twisting planes or movable rudders.

3. By doing away even with the air propeller and making direct use in the form of reactive force of the motor explosions.

4. By distributing the force of these explosions to the surrounding atmosphere by a suitable arrangement of pipes located in the supporting surfaces with nozzles on both the under and upper sides of these surfaces. These nozzles should be so arranged that the emitted gases should strike the atmosphere at an angle of 45 degrees with the horizontal, so as to produce forward motion as well as upward and downward push for automatic equilibrium. The equilibrium will be maintained automatically by suitable valves, and consequently the angle of attack will be kept as constant as possible. The valves can be made to act in response to a tilting of the monoplane of less than one degree.*

5. The steering, instead of being accomplished by rudders, will also be done by reactive force of explosions controlled by hand-operated valves.

Twistable, movable planes give too much head resistance when used for the purpose of steering. Besides, they are breakable and get uncontrollable, particularly at great speed.

6. The arrow-shaped, wedge-form monoplane will compress the surrounding air, so the reactive force will act on comparatively hard air.

7. Under forward motion of this monoplane, with outlets for the reactive force set at an angle of 45 degrees in the supporting surfaces, the reactive force strikes fresh, untouched atmospheric air all the time.

8. The faster the monoplane is flying, the more compressed the surrounding air becomes; and the more the air gets compressed, the better for the action of the reactive force, which will force the monoplane to go still faster and compress the air still more. This in turn results in greater speed and harder compressed air and so on, up to a certain limit, the speed getting faster and faster, and all this without the motive power being augmented in any way.

9. It is important to mention in this connection that, on the other hand, Langley's law is: "The weight remaining the same, the force requisite to sustain inclined planes in horizontal motion diminishes instead of increasing when the velocity is augmented."

10. So the necessity for experiments with reactive force and a monoplane of the arrow-shaped form with automatic balance is very great. With no hindrance to speed by movable and twisting planes and with the angle of attack kept constant, the speed will be enormous; and consequently, at great speed, the monoplane will carry more weight, with smaller area of supporting surfaces; while last, but not least, it will carry it with less motive power.

11. The experiments going on now with the double surface and box-kite form and other types of flying machines, even if they are successful to a certain extent, will nevertheless sooner or later prove conclusively that the only really successful aeroplane has to be of the type described in this article. Before too much money is wasted in the wrong direction, a committee ought to be appointed to investigate the plans closely and a fund ought to be furnished to experiment with the reactive-force-driven, automatically-balanced-and-steered, arrow-shaped, wedge-form monoplane.

12. If reactive force has not been managed very successfully in the past, it does not follow that this cannot be done in the future.

13. The opinion that reactive force cannot be made sufficiently powerful cannot be sustained in the absence of any evidence.

14. In conclusion, attention is called to the article in the Aérophile of November, 1907, pages 321 and 322, and also to the Aérophile of March 1, 1908, page 83, where M. Réné Lorin proves by his diagram that reactive force is a much more effective propelling medium for aeroplanes than the usual air propeller.

To Clean and Curl Plumes.—In 3 parts by weight of rain water, boil 50 to 60 parts of white soap and allow it to cool. The feathers, dipped in water, are spread on a table and washed with a linen rag, dipped in the above soap water, rinsed off with lukewarm water, well pressed out and folded between clean linen cloths, after they had been dried as nearly as possible, by striking with the open hand. Red-hot coals are then spread out and the plumes, in both parts, held high above them and turned over and over until they are dry and nicely curled. If we have white plumes to dry, we may sprinkle a little powdered sulphur on the coals and allow the fumes to pass through them, by which means they are rendered perfectly white.

* It would go too far to explain in this article how this can be done Particulars can be found in—

United States Patent 730107, June 2, 1903.
United States Patent 825881, July 10, 1906.
British Patent 14008, June 19, 1906,
French Patent 367867, S. G. D. G., July 7, 1906,

and particularly in my descriptions and photographs of experiments which I made with the system of automatic balance. Particulars also in my letters of correspondence with authorities.

ELECTRICAL NOTES.

Simultaneously with the organization of a pigeon postal service in the French Congo, where the climate makes both ordinary and wireless telegraphy impossible, it is announced that the British government has replaced the pigeon post by wireless telegraphy in both the naval and the colonial service, and that this year's budget contains no appropriation for pigeons.

After centuries of inaction, China is waking up and demanding every western improvement and invention. A few years ago Peking was one of the dirtiest and most disorderly cities on earth. It had no street-cleaning service and scarcely any police. Now it is rapidly becoming a model city. A striking example of the change that has taken place in the mental habits of the people is afforded by the telephone system, which already has 1,700 subscribers and is being rapidly extended.

There are only a few electric traction lines on the Continent which are using single-phase current. One of these is the line which runs from Vienna to Baden. Counting the part within the city, the total length is about 20 miles. The road is supplied with current from a station situated near Baden, and this current is brought to the road at a high tension of 10,000 volts. A series of transformer posts placed along the line receive this current, and it is here reduced to a low tension of 550 volts for use on the trolley wire. These posts consist of square towers of 22 feet height. As to the rolling stock in use on the line, it consists of motor cars and trailers. The motor cars carry four motors, which give a total of 160 horse-power. Between Vienna and Baden most of the road is laid out on the single-phase system. Within the towns and for a short section of line in the suburbs, the ordinary direct-current system is used.

MacQuat and Lorenz have obtained a United States patent for a new process of preparing electric-lamp filaments. The process consists in covering a carbon filament with a mixture of silicon with a metal or metals. The carbon filament is immersed in a solution of sugar which contains the silicon and metals in a state of suspension. The filament is then dried and heated to incandescence in an inert gas. At this high temperature the silicon combines with the metals, and the filament becomes coated with metallic silicides. In a modification of the process the filament is saturated with a solution of silicides, and in another modification the filament is made of dissolved cellulose with which silicides have been incorporated. Lamps containing the new filaments have shown a life of 400 hours and a consumption of energy equal to 1.8 watts per candle-power.

An important system of electrical transmission of power installed in the States of Michoacan and Guanajuato, Mexico, was very seriously disturbed by lightning in the rainy seasons of 1904 and 1905. The line is 100 miles long, and is carried on steel towers about 40 feet high. Two of the three wires of the system are attached to a horizontal steel arm on each tower, and the third wire is carried on insulators at the tops of the towers. The wires are about 4 feet apart, and the difference of potential between them is 60,000 volts. During the stormy season of 1904, the first year of service, most of the insulators, and especially those on top of the towers, were destroyed by lightning. In the following winter each tower was provided with a lightning conductor formed of two metal rods inclined at an angle of 30 deg. to the vertical and electrically connected with the ground. In consequence of this protection, the insulators sustained comparatively little damage in the ensuing stormy season, but the wires were often struck by lightning between the towers. A steel cable, in electrical communication with the ground, was then stretched from tower to tower, just above the highest of the service wires. In the section of the line to which this additional protection was given, a further diminution in the number of lightning strokes was noted in the rainy season of 1906.

Prof. Richter attributes many explosions in factories to static electrical charges on swiftly-running belts. The electrification appears to be favored by the application of resinous substances to the belts for the purpose of increasing their adhesion to the wheels. Experiments made with a leather belt about 5 inches wide showed, in the middle of the belt, charges of a positive potential of 13,000 volts, which gave sparks one inch long. The wheel which carried the strap was charged negatively. A one-inch spark is quite capable of igniting the explosive mixtures of air with inflammable gases or powders that are produced in certain industries. The electric charge increases with the dryness of the belt and the air. It appears to be independent of the tension of the belt. Experiments have been made with bronze powder and other pulverized metals, which are good conductors of electricity, as substitutes for rosin for increasing the adhesion between belt and wheel. These powders work well at first, but soon drop off. The application of glycerine, on the other hand, has given very good results. Owing to the hygroscopic nature of glycerine, the strap always remains moist and consequently a good conductor, so that it cannot accumulate electric charges. The glycerine should be absolutely free from acid. The best results are obtained with equal parts of water and of the official glycerine of 28 deg. Baumé. The mixture is applied with a sponge. The application of glycerine has the additional advantage of keeping the belt in good condition and lengthening its term of service.

SCIENCE NOTES.

Dr. Variot points out the disorders, often grave, which are produced in infants by the habitual use of milk substitutes containing cocoa. Among these disorders are constipation, nervous excitement, anæmia, sallowness and œdema of the face, and retarded development. The poisonous effect of cocoa is probably due to the large quantity of oxalic acid which it contains—4.5 per cent. This is more than the quantity of oxalic acid—3.5 per cent—contained in sorrel.

During the past few decades there has been gradually developing in the biological world a clearer recognition of the importance of a study of function, coupled with a fuller appreciation of the great diversity of the processes characteristic of life. It has come to be the fashion for naturalists—who up to comparatively recent times were content mainly to study form and structure—to turn their attention to observation of function, to learn how and why certain things are accomplished. Each decade has witnessed a broadening of the point of view; in botany, zoology, paleontology, and geology new methods of investigation have been gradually applied, new relationships have been established, and the study of life, past and present, has taken on a new and broader significance. The Mendelian law and the present theories of genetics, the facts of modern cytology and the theories of heredity consequent thereto, the present-day experiments in breeding and variation with the conclusions to be drawn therefrom, the modern methods and theories of physiology in general, are the natural outcome of a progressive scientific activity where the study of function has come to occupy a prominent position and where the experimental method is being largely applied in biology as in the physical sciences.

Berndt, of the University of Halle, has devised a new method of measuring the degree of exhaustion of incandescent electric bulbs, X-ray tubes, and other high-vacuum apparatus. A hot wire loses heat both by radiation and by convection, the loss by convection diminishing as the pressure of the surrounding air or gas is reduced. Hence, the temperature of a wire traversed by a constant electric current in a closed vessel which is being exhausted will rise as the vacuum improves. As the wire becomes hotter its length increases, and if it is stretched horizontally the extent to which it sags will give a measure of the degree of exhaustion. In practice, Berndt employs a silver wire about 1/100 inch in diameter and 6 inches long, mounted in a glass tube between platinum electrodes. The tube is connected with the vessel in which the exhaustion is to be measured. The sagging of the wire is measured with a microscope provided with a micrometer. The wire is loaded at its middle point with a little disk of copper or aluminium, and its annoying oscillations are damped by the action of the Foucault currents induced in the disk by a magnet between the poles of which it is suspended. This apparatus has given very good results. It can also be adapted to close a circuit and give an electric signal when the desired degree of exhaustion has been obtained.

Changes in the appearance of the lunar surface, particularly in the vicinity of the crater Linnaeus, have repeatedly been seen by various observers. Pickering observed a gradual diminution, at local sunrise, of the area of the white patch which surrounds the crater, and the discovery has been confirmed by Barnard, of Yerkes observatory, and by observations made by Frost and Stabbius during a lunar eclipse. Prof. Pickering attributes the change to the melting of hoar frost by the rays of the rising sun. In this connection Dr. Wirtz observes that an apparent increase in the area of the white patch can be produced by interposing colored glass between the objective and the eye piece. Hence he concludes that the augmentation of the spot which is observed in lunar eclipses is a purely subjective phenomenon due to the decrease in illumination. Prof. Pickering, however, finds that the increase in the area of the patch during an eclipse is much greater than the increase produced by colored glass. Moreover, it has often been observed that the patch was larger after the end of the eclipse than it was before its commencement. If the phenomenon were purely subjective and due to darkness, it would not persist after the passage of the earth's shadow. Hence Prof. Pickering concludes that the observed changes are caused by the deposition and melting of hoar frost and that they must occur, under similar conditions, in all parts of the surface of the moon.

TRADE NOTES AND FORMULÆ.

To Clean and Disinfect Bed Feathers.—Separate the and remove dust in a willow, then place them in wide, open copper cone, underneath which is a kett of boiling water. The steam passes through the pe forated lid into the feathers and heats them to 2 deg. The feathers are then transferred to hot she metal plates and dried, then again spread on a gra under which is placed a vessel containing chloride lime, from which, by means of admixed acid, chlori gas is generated, which permeates the feathers.

Fire Extinguishers.—

Fire-Extinguishing Composition (according Grü berg).—20 parts chlorate of potash, 10 parts rosin, parts potash niter, 50 parts of sulphur, 1 part perox of manganese. Great care is to be recommended account of danger of explosion while making up.

Fire-Extinguishing Composition (according Zeisler).—60 parts of saltpeter, 36 parts of sulph 4 parts of charcoal and lime; compressed by hydrau pressure into cartridges and several inclosed, tight, in capsules, provided with a fuse.

Fire-Extinguishing Composition (according to Jo stone).—Equal parts of chlorate of potash, rosin, p ash niter and manganese are moistened with solu glass, pressed into blocks and inclosed in boxes, which several, connected by quick fuse, are suspend from the ceiling of the room.

Fire-Extinguishing Cartridges (Bucher's).—Sa peter 66 parts, sulphur 30, charcoal 4 parts, fin ground, mixed into a paste with water and the pa pressed into paper boxes. The cartridges are thro on the burning object.

Fire-Extinguishing Flasks (Grenades).—In 30 pa of water dissolve about 5 parts of ammoniacal s and 10 parts of common salt. The solution is pou into bottles that are tightly closed and placed in convenient location in each room. Dash one of bottles on the burning object with sufficient force break it. The effect is said to be instantaneous.

Fire-Extinguishing Medium.—50 parts of com salt, 30 parts of bi-carbonate of soda and 20 parts alum. All finely pulverized and mixed. Method use, dissolve the powder in water (5 per cent powd 1 per cent water).

Fire-Extinguishing Medium.—In receptacles m of parchment paper or lead foil, we first place 4 pa of a double salt made with 343 parts of sulphate aluminium and 142 parts of sulphate of sodium, w 432 parts of water. Then, separated from this by cross partition of parchment paper, 1 part of sulph of sodium. When using, the package is broken a the contents emptied into the water used for ext guishing purposes.

Fire-Extinguishing Medium (Hayward's Hand G nades).—Solution of 18.4 parts of chloride of calciu 5.7 parts of chloride of magnesia, 1.3 parts of chlori of sodium, 2.2 parts of bromide of potassium, 0.3 p of chloride of barium and 72.2 parts of water.

Fire-Extinguishing Preparation.—*a*. The so-cal Munich fire extinguisher consists of 43 parts co mon salt, 19.5 parts of alum, 5 parts Glauber salt, parts soda, 6.6 parts soluble glass and 22.3 parts water. *b*. The Vienna fire extinguisher is a solut of 4 parts of green vitriol and 16 parts of ammoni sulphate in 100 parts of water. *c*. A mixture 30 p of alum, 65 parts of sulphate of ammonia, and 5 p of green vitriol can also be used.

Fire-Extinguishing Medium.—Dissolve 9 parts common salt and 4.5 parts of sal ammoniac in parts of water; fill with it bottles of thin glass distribute them in the house in readily acces places. In case of fire, throw several of the bot into the burning spot.

Fire-Extinguishing Medium (Link's).—20 parts boracic acid and 25 parts of green vitriol are solved in 200 parts of hot water and this slowly po into a cold solution of 30 parts of hyposulphite soda, 50 parts of soluble glass (silicate of soda), 800 parts of water, steadily stirring all the time.

Fire Protective Medium (Thouret's) for Impreg tion or Coating.—Solution of 3 parts of phosphate ammonia, 2 parts of sal ammoniac, 1 part of sulp of ammonia, and some chloride of lime, in 45 parts water.

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